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INSTRUCTION MANUAL
MODEL 1501L-P

California INSTRUMENTS

Invertron® AC POWER EQUIPMENT

Convertron™ DC POWER EQUIPMENT

MP MASTER
MA28332

California Instruments Corporation

9025 Balboa Avenue, San Diego, CA 92123-1509
(619) 279-8620 (800) 4-AC-POWER
FAX (619) 279-8139

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California INSTRUMENTS

INSTRUCTION MANUAL

MODEL 1501L-P

Invertron®

TABLE OF CONTENTS

SECTION	TITLE	PAGE
1	INTRODUCTION AND SPECIFICATIONS.	1-1
	1-1 INTRODUCTION	1-1
	1-2 GENERAL DESCRIPTION.	1-1
	1-3 ACCESSORY EQUIPMENT/RACK SLIDES.	1-1
	1-4 SPECIFICATIONS	1-1
2	INSTALLATION AND ACCEPTANCE.	2-1
	2-1 UNPACKING.	2-1
	2-2 POWER REQUIREMENTS	2-1
	2-2-1 AC LINE VOLTAG	2-1
	2-2-2 LINE FREQUENCY OPERATING RANGE . . .	2-1
	2-2-3 INPUT POWER.	2-1
	2-3 INPUT VOLTAGE RANGE SELECTION.	2-1
	2-3-1 LOW INPUT VOLTAGE RANGE CONFIGURATION	2-2
	2-3-2 HIGH INPUT VOLTAGE RANGE CONFIGURATION	2-2
	2-4 MECHANICAL INSTALLATION.	2-4
	2-5 INPUT WIRING	2-4
	2-6 OUTPUT CONNECTIONS	2-4
	2-7 OUTPUT VOLTAGE RANGES.	2-5
	2-8 FUNCTION TEST.	2-5
3	OPERATION.	3-1
	3-1 GENERAL.	3-1
	3-2 FRONT PANEL CONTROLS	3-1
	3-3 FRONT PANEL INDICATORS	3-1
	3-4 REAR PANEL CONNECTIONS	3-3
	3-5 FRONT PANEL PROGRAMMING.	3-7
	3-5-1 KEYPAD	3-7
	3-5-2 DISPLAY SCREENS.	3-9
	3-5-3 TO PROGRAM OUTPUT VOLTAGE AMPLITUDE (AMP=5)	3-14
	3-5-4 TO PROGRAM FREQUENCY (FRQ=6)	3-14
	3-5-5 TO PROGRAM OUTPUT PHASE ANGLE (PHZ=7)	3-14
	3-5-6 TO PROGRAM CURRENT LIMIT (CLR=8) . .	3-15
	3-5-7 TO PROGRAM VOLTAGE RANGE (RNG=4) . .	3-15
	3-5-8 TO PROGRAM RAMP OR STEP FUNCTION (RMP=9).	3-15
	3-5-9 TO PROGRAM THE OUTPUT WAVEFORM (WVF=3).	3-18
	3-5-10 TO PROGRAM EXTERNAL SYNCHRONIZATION	3-18
	3-5-11 TO PROGRAM THE EXTERNAL CLOCK (CLK=2)	3-19
	3-5-12 TO PROGRAM REGISTERS AND RAMPS	3-20
	3-5-13 REGISTER LINKING	3-20
	3-5-14 TO PROGRAM SIMULTANEOUS RAMPS. . . .	3-21
	3-5-15 ERROR MESSAGES	3-22

SECTION	TITLE	PAGE
6	MAINTENANCE AND TROUBLESHOOTING.	6-1
	6-1 GENERAL.	6-1
	6-2 POOR VOLTAGE ACCURACY.	6-1
	6-3 POOR OUTPUT VOLTAGE REGULATION	6-1
	6-4 OVERTEMPERATURE LAMP ON.	6-2
	6-5 OVERLOAD LAMP ON	6-2
	6-6 CAN'T PROGRAM AC POWER SYSTEM ON GPIB. .	6-2
	6-7 DISTORTED OUTPUT	6-3
	6-8 NO OUTPUT.	6-3
	6-9 MODULE REMOVAL	6-4
	6-10 OSCILLATOR MODULE REMOVAL/REPLACEMENT. .	6-4
	6-11 AMPLIFIER REMOVAL/REPLACEMENT.	6-4
7	REPLACEABLE PARTS.	7-1
	7-1 GENERAL.	7-1
	7-2 ORDERING INFORMATION	7-1

LIST OF ILLUSTRATIONS

FIGURE	DESCRIPTION	PAGE
1-1	California Instruments Model 1501L	1-2
2-1	1501L Rear Panel Connections	2-3
2-2	Function Test Setup	2-7
3-1	Front Panel Controls and Indicators	3-2
3-2	Function Strobe Connections	3-7
3-3	Keypad	3-7
3-4	Remote Command Sequences	3-30
3-5	CIIL Program Syntax	3-51
3-6	Confidence Test Flow Diagram	3-55
4-1	Internal Adjustments and Jumper Locations	4-3
4-2	Equipment Hookup for Periodic Calibration	4-4
4-3	Remote Calibration Flow Diagram	4-8
5-1	AC Power Source Block Diagram	5-5
5-2	Programmable Oscillator Module	5-6
6-1	Module Location	6-6

LIST OF TABLES

TABLE	DESCRIPTION	PAGE
1-1	Specifications	1-3
2-1	Minimum Wire Size	2-4

TABLE	DESCRIPTION	PAGE
3-1	Power Output Terminal	3-3
3-2	Remote Sense Input Connector	3-3
3-3	System Interface Connector (J7)	3-4
3-4	Keypad Key Description	3-8
3-5	Output Parameter Screen	3-10
3-6	Measurement Screens	3-11
3-7	Calibration Screen	3-11
3-8	Configuration Screen	3-13
3-9	Front Panel Display Error Messages	3-23
3-10	Commonly Used GPIB Abbreviations	3-26
3-11	Unit Address Group	3-27
3-12	Program Headers	3-33
3-13	TLK Arguments	3-41
3-14	Example Talk Response	3-43
3-15	Status Byte Values	3-47
3-16	HP Series 80 Controller Statement	3-48
3-17	Channel Designators and Noun Modifiers	3-53
3-18	Non-CNF Status Messages	3-57
3-19	Discrete Fault Interrupt Conditions	3-63
3-20	Sample Programming Strings	3-64
6-1	Troubleshooting	6-1

SECTION 1

INTRODUCTION AND SPECIFICATIONS

1-1 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration, and maintenance of the California Instruments Model 1501L-P. The 1501L-P will hereafter be referred to as the AC Power Source.

1-2 GENERAL DESCRIPTION

This instrument is a high efficiency power source that provides a low distortion sine wave output. The AC Power Source can supply up to 1500VA. Full power is available from either a 0 to 135 volt range or 0 to 270 volt range. Full power is available from 45 Hz to 5 KHz. The AC Power Source is illustrated in Figure 1-1.

1-3 ACCESSORY EQUIPMENT/RACK SLIDES

Zero Manufacturing Company Model CTN-1-20-E94 rack slides may be attached to the sides of the power source using 8-32 X 3/8 flat head screws

1-4 SPECIFICATIONS

Table 1-1 contains the operation specifications of the AC Power Source. All specifications are tested in accordance with standard California Instruments test procedures. The following specifications apply for operation at 100% of full scale voltage, constant line voltages and under no-load conditions unless specified otherwise.

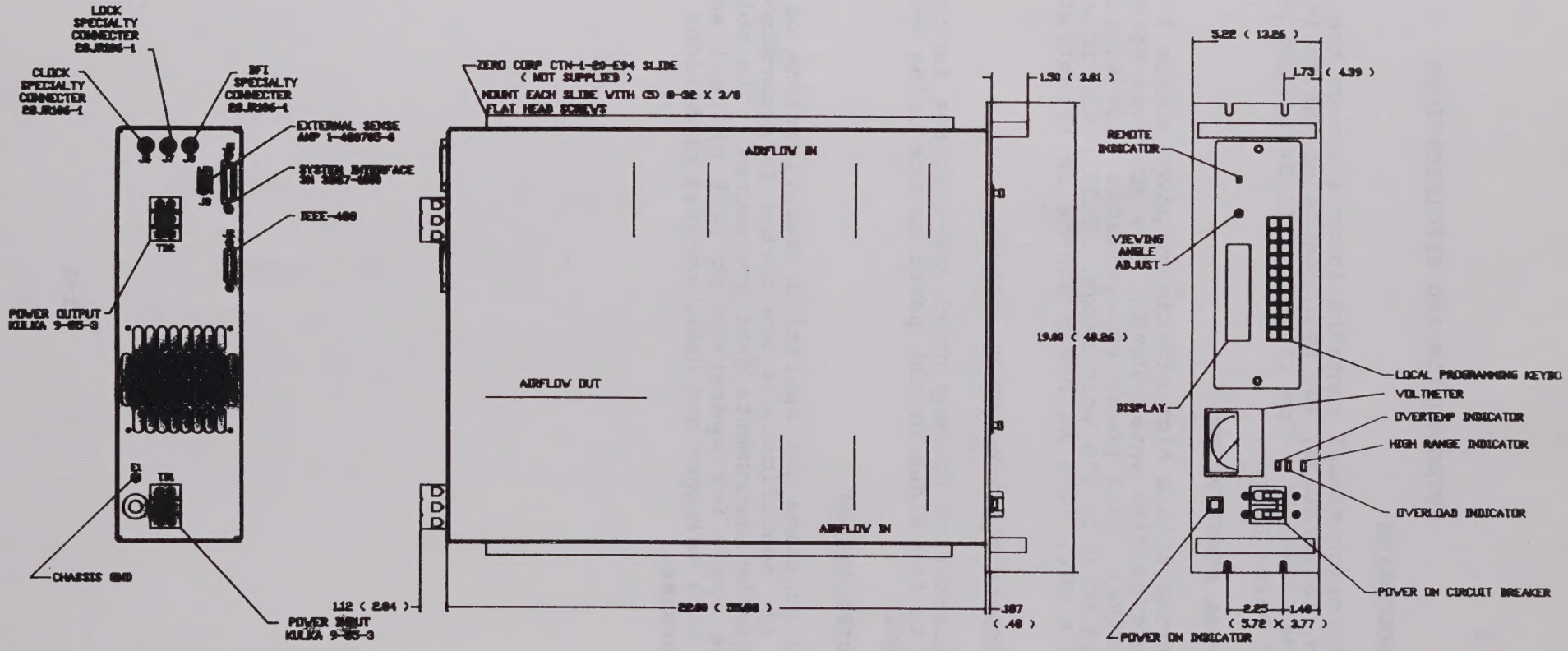


FIGURE 1-1
CALIFORNIA INSTRUMENTS 1501L

TABLE 1-1

1501L-P SPECIFICATIONS

ELECTRICAL

Input

Line voltage:	103 - 127 VAC, 207 - 253 VAC.
Line frequency:	47 - 440 Hz.
Efficiency:	75% typical.

Surge current (turn-on) 185 amps at high line voltage.

Output

Total power:	1500 watt
Power/phase:	1500 watt
Power factor:	0 to 1.0.
Current/phase:	11.12 Amps at 135 volt range. 5.56 Amps at 270 volt range.
Peak current/phase (repetitive)	27.8 Amps at 135 Voltage Range. 13.9 Amps at 270 Voltage Range.
Peak current/phase (nonrepetitive)	30.0 Amps at 135 Voltage Range. 15.0 Amps at 270 Voltage Range.
Full Current /Output Voltage	See attached chart
Voltage range:	135/270 volts
Total Distortion (to 300 KHz)	1% up to 2 KHz, 2% up to 5 KHz.
Signal to noise ratio (20 KHz to 1 MHz)	50 dB
Line regulation:	0.02% of full scale for ±10% of input line voltage.
Load regulation:	0.05% of full scale from no load to full load.

Voltage accuracy (at no load):
±0.1% of full scale at 135 volt Range
±0.2% of full scale at 270 volt Range.

Voltage temperature coefficient:
±0.02 of full scale/°C.

Voltage stability (24 hours):
±0.015% of full scale under constant load, line and temp.

Frequency range: 45 Hz to 5 KHz.

Frequency accuracy: ±0.001% of programmed value.

Frequency temperature coefficient:
±5 ppm per degree C.

Frequency Stability:
±15 ppm per year.

Warm-up time: 15 minutes.

Isolation: 500 Volts rms input to output.

PROTECTION

Output overload: Default to 5.0 volts and open output relay, no recovery.

Output short circuit:
Default to 5.0 volts and open output relay, no recovery.

Sense Line Fault: Default to 5.0 volts and open output relay, no recovery.

Overtemperature: Default to 5.0 volts and open output relay, no recovery.

MEASUREMENTS

Voltage accuracy:	±1.0 Volt.
Voltage resolution:	0.1 Volt.
Current accuracy:	±0.1 Amps.
Current resolution:	1 Watt.
True power accuracy:	±10 Watts
Apparent power resolution:	0.01 Amps.
Power factor resolution:	0.001.
Frequency accuracy:	±0.02 Hz to 99.99 Hz, ±0.2 Hz to 499.9 Hz, ±0.5 Hz to 999.9 Hz, ±10 Hz to 5000 Hz.

CONTROL

Front panel controls:

- Power on/off circuit breaker with indicator.
- 20 Key Keypad.

Bus: IEEE 488.

- Subsets: SH1, AH1, T6, L3, SR1, RL2, DC1, DT1.
- Codes and formats:
  - Numeric NR1, NR2, or NR3.
  - Headers: HR1 or HR2.
  - Message separators: SR1.
- Data transfer rate 200K bytes/ second. DMA mode.
- Language: California Instruments language that is upward compatible from other C.I. products.

Functions

Voltage:

Range:	0 to voltage Range
Resolution:	0.1 Volt
Initialization:	5.0 Volts

Voltage range:

Range:	135/270
Resolution:	0.1 Volt.
Initialization:	135 Volt Range.

Frequency:

Range:	45 to 5000 Hz.
Resolution:	0.01 Hz from 45 to 99.99 Hz, 0.1 Hz from 100 to 999.9 Hz, 1 Hz from 1000 to 5000 Hz.
Initialization:	60 Hz std.

Current limit:

Range:	0 to 11.12 Amp at 135V range 0 to 5.56 Amp at 270V range
Resolution:	0.01 Amp
Initialization:	Maximum value of range

Phase Angle: (to external sync only)

Range:	0 to 999.9 degree
Resolution:	0.1 degree
Initialization:	Last setup value

Sync:

Range:	Internal/External
Initialization:	Internal

Clock: (Option only)

Range:	Internal/External
Initialization:	Internal

Waveform: (Option only)
Range: Sine wave/square wave
Initialization: Sine wave.

Sweep/step:
Of voltage, frequency, current up to two functions simultaneously.

Calibrations:
Of output voltage and Measurement functions

Service request:
Remote function only with option to enable and disable after errors, faults, and end of measurements.

Status:
Remote Status Byte and Status Message.
Display Status Message only.

Group Execute Trigger:
Remote function only, Trigger setups and terminate programs.

Registers and Register Linking:
16 Register will store programmable parameter with abilities to link them to each other.

FEATURES:

Remote on:
A logic low input program, the output to 5.0 volt and open the output relay.

Output Relay:
Normally open at power up. In local control, relay will close with the first programmable function. Output Relay can be controlled remotely.

Function Strobe:
400usec low logic output level when voltage and frequency is programmed.

External Sync:
A TTL logic level with a frequency of 45 Hz to 5 KHz as an input. The output will tack the frequency and phase of the input.

Remote Sense:
Will compensate for 10% of drop in output voltage.

Indicators:
Power on, high voltage range, overtemperature, output overload, and 2 lines 16 character each LCD type display.

Elapse Time Indicator:
Display the accumulated Power on time.

Options:

Output Voltage Ranges:

High Voltage:	156/312
Low Voltage:	67.5/135

Master:
Must use LK Option

Slave:
Must use LK Option

Square Wave:

Rise:	40usec.
Droop:	10%
Overshoot:	20%

MATE:
Use CIIL language with Confidence Test.

SYSTEMS

None

MECHANICAL

Dimensions: 5.25 x 19 x 22 + 1 for connector.

Weight: 75 lbs

Material: Aluminum front panel, steel chassis.

Finish: Gray 26440 per Fed Std 595.

Air intake/exhaust: Sides/rear.

Modularity: Modules interconnected with motherboard.

Connectors: Input - Kulka 9-85-3.
Output - Kulka 9-85-3.
Sense - Amp 1-480705-1.
Interface - 3M3367-1000.

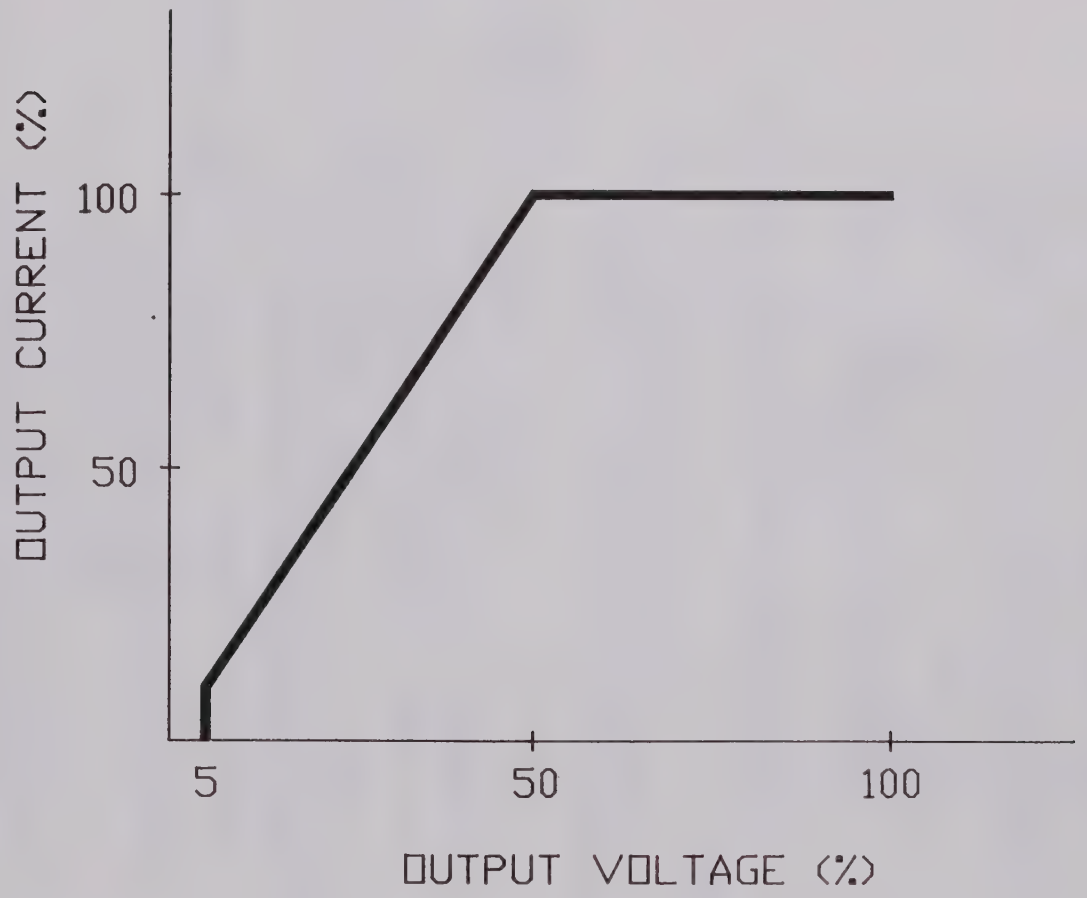
Chassis slides: Zero Manufacturing CTN-1-20-E94.

ENVIRONMENTAL AND QUALITY

Operating temperature: 0 to 50°C.

Storage temperature: -40 to 85°C.

Operating altitude: 0 to 6000 feet.



FULL CURRENT/OUTPUT VOLTAGE

SECTION 2

INSTALLATION AND ACCEPTANCE

2-1 UNPACKING

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. DO NOT return an instrument to the factory without prior approval. Do not destroy the packing container until the unit has been inspected for damage in shipment.

2-2 POWER REQUIREMENTS

2-2-1 AC Line Voltage

The AC Power Source has been designed to operate from either of the following AC line voltage ranges:

1) 104 to 126 volts
2) 207 to 253 volts.

CAUTION

The AC Power Source will be damaged if it is operated at an input voltage that is outside its configured input range.

The input voltage range is set at the factory. Section 2.3 gives the procedure to change the input voltage range.

2-2-2 Line Frequency Operating Range

The AC Power Source has been designed to operate over the line frequency range from 47 Hz to 440 Hz.

2-2-3 Input Power

The input power to the AC Power Source depends upon line and load conditions and may be as high as 2000 watts.

2-3 INPUT VOLTAGE RANGE SELECTION

WARNING

Voltages up to 360 VDC and 270 VAC are present in certain sections of this power source. This equipment generates potentially lethal voltages.

DEATH
on contact may result if personnel fail to observe safety precautions. Do not touch electric circuits when power is applied. Servicing should only be performed by trained personnel.

The input voltage range is configured by two wires and eight jumpers. See Figure 6-1 for the location of the A6 board (DC Supply) where the jumpers are located.

2-3-1 Low Input Voltage Range Configuration

Remove input power at the rear panel of the power source before attempting to change the voltage range configuration.

The low input voltage range is set by making the following connections inside the power source:

Wire W5	4005-050-005	From CB1B-LN to A6-E2.
Wire W11	4005-050-011	From DS1 to A6-E7.

Jumper A6-J1	From 2 to 5.
Jumper A6-J1	From 3 to 4.
Jumper A6-J2	From 2 to 5.
Jumper A6-J2	From 3 to 4.
Jumper A6-J3	From 2 to 5.
Jumper A6-J3	From 3 to 4.
Jumper A6-J4	From 2 to 5.
Jumper A6-J4	From 3 to 4.

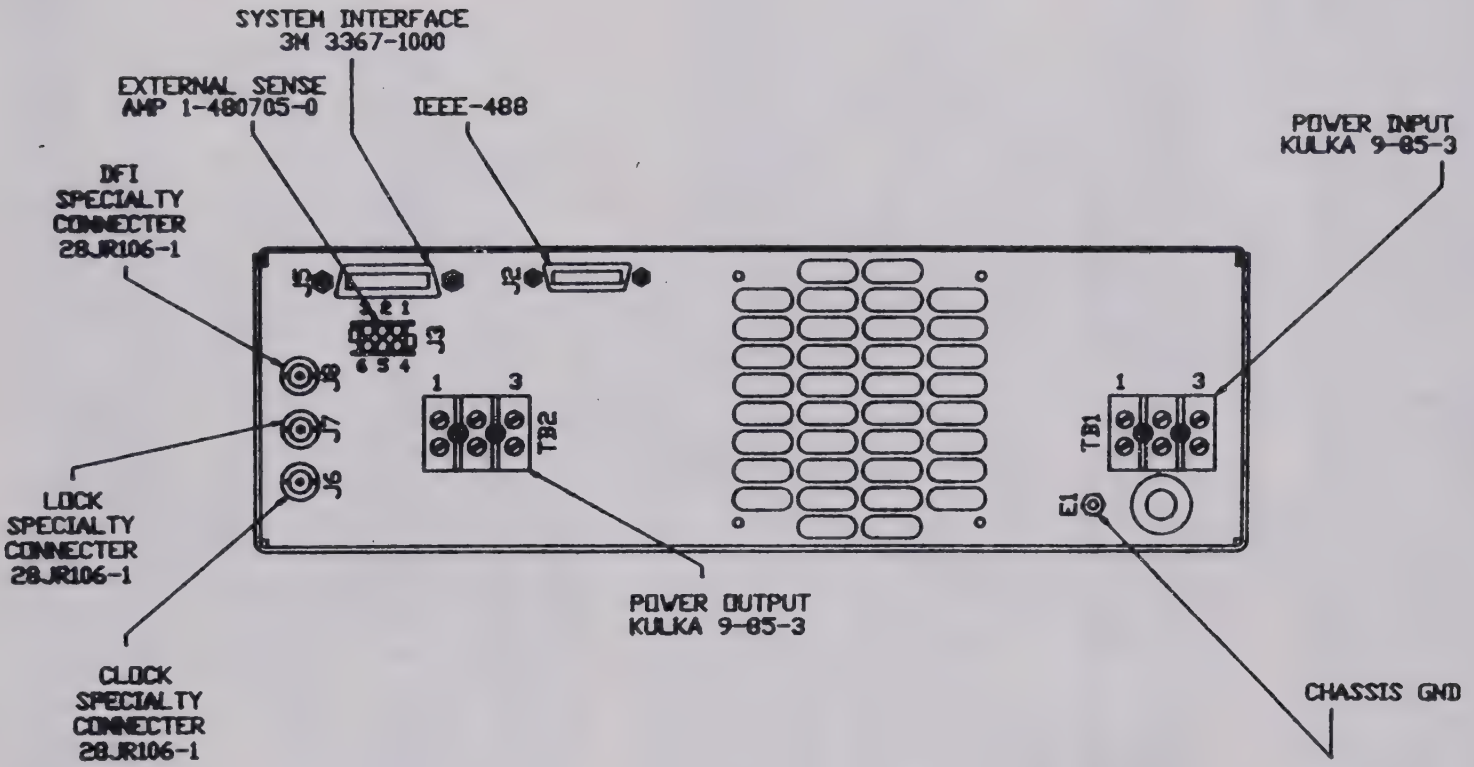
2-3-2 High Input Voltage Range Configuration

Remove input power at the rear panel of the power source before attempting to change the voltage range configuration.

The high input voltage range is set by making the following connections inside the power source:

Wire W5	4005-050-005	From CB1B-LN to CR1-AC.
Wire W11	4005-050-011	From DS1 to A6-E4.

Jumper A6-J1	From 1 to 6.
Jumper A6-J1	From 2 to 3.
Jumper A6-J2	From 1 to 6.
Jumper A6-J2	From 2 to 3.
Jumper A6-J3	From 1 to 6.
Jumper A6-J3	From 2 to 3.
Jumper A6-J4	From 1 to 6.
Jumper A6-J4	From 2 to 3.



TB1

PIN	FUNCTION
1	HI INPUT
2	LO INPUT
3	GND

J3

PIN	FUNCTION
1	Ø C SENSE
2	Ø B SENSE
3	Ø NEUT SENSE
4	Ø A SENSE

TB2

PIN	FUNCTION
1	HI OUTPUT
2	LO OUTPUT
3	GND

FIGURE 2-1
1501L REAR PANEL CONNECTIONS

2-4 MECHANICAL INSTALLATION

The power source has been designed for rack mounting in a standard 19 inch rack. The unit should be supported from the sides with optional rack slides. See Accessory Equipment/Rack Slides in paragraph 1-3. The cooling fan at the rear of the unit must be free of any obstructions which would interfere with the flow of air. A 2.5 inch clearance should be maintained between the rear of the unit and the rear panel of the mounting cabinet. Also, the air intake holes on the sides of the power source must not be obstructed. See Figure 1-1.

2-5 INPUT WIRING

The AC Power Source must be operated from a three-wire single phase service. The mains source must have a current rating greater than or equal to the AC Power System circuit breaker, 30 amps. Refer to Figure 2-1 for the input power connections.

2-6 OUTPUT CONNECTIONS

The output terminal block, TB1, is located at the rear of the power source. All load connections must be made at TB1. The remote sense inputs allow the power source output voltages to be monitored directly at the load and must be connected. The remote sense wires are connected at J3 on the rear panel.

The output power cables must be large enough to prevent a voltage difference greater than 3.5 VRMS between TB1 and the voltage between Remote Sense HI and LO input. Table 2-1 shows the maximum length of the output wires. The table assumes the Remote Sense input is connected at the load.

TABLE 2-1

MINIMUM WIRE SIZE

MAXIMUM OUTPUT CURRENT IN AMPS	WIRE GAGE (AWG)	MAXIMUM LENGTH (in feet) WIRE BETWEEN OUTPUT AND LOAD
11.11	20	14
11.11	14	59
11.11	12	94

The Remote Sense inputs must be connected or an AMP FAULT error message will be shown on the display and reported through the remote interface.

2-7 OUTPUT VOLTAGE RANGES

The standard voltage ranges for this AC Power Source are 135 and 270. Selecting of the 270 volt range causes the front panel "HIGH RANGE" lamp to illuminate. The range may be changed from either the front panel keypad or through the GPIB input.

2-8 FUNCTION TEST

Refer to Figure 2-2 for the test setup.

Perform the following test sequence.

1) Apply the AC line power and turn on the front panel circuit breaker. No loads should be connected to the output terminal block.

2) Verify that the POWER ON lamp is lit.

3) With the front panel keypad program the 270 range with the following key sequences:

   4 ENT — To select the Range screen (RNG)

   270 PRG ENT — To program the 270 range

4) Verify the HIGH RANGE lamp is lit.

5) Program the output to 270 volts with the following key sequences:

   Depress the MON key 1 time to select the Amplitude screen (AMP).

   270 PRG ENT — To program the voltage to 270 volts

6) Verify that the front panel voltmeter indicates approximately 270 volts.

7) Program the AC Power Source to the 135 volt range with the following keystrokes:

   4 ENT 135 PRG ENT

8) Program the output to 135 volts:

   5 ENT 135 PRG ENT

9) Observe the output with the oscilloscope or distortion analyzer. The output should be a clean sine wave having less than 1.0% distortion.

10) Apply a full load (12.4 ohms, 1500 watts). Verify that the output voltage remains within 0.067 volts of the no-load voltage. The waveforms shall still appear clean on the oscilloscope and have less than 1% distortion.

11) Program the Current Limit to 5.0 amps:

    8 ENT

    5 PRG ENT

12) The display should show the error message 'AMP FAULT'. The output will default to a programmed value of 5.0 volts with the output relay open.

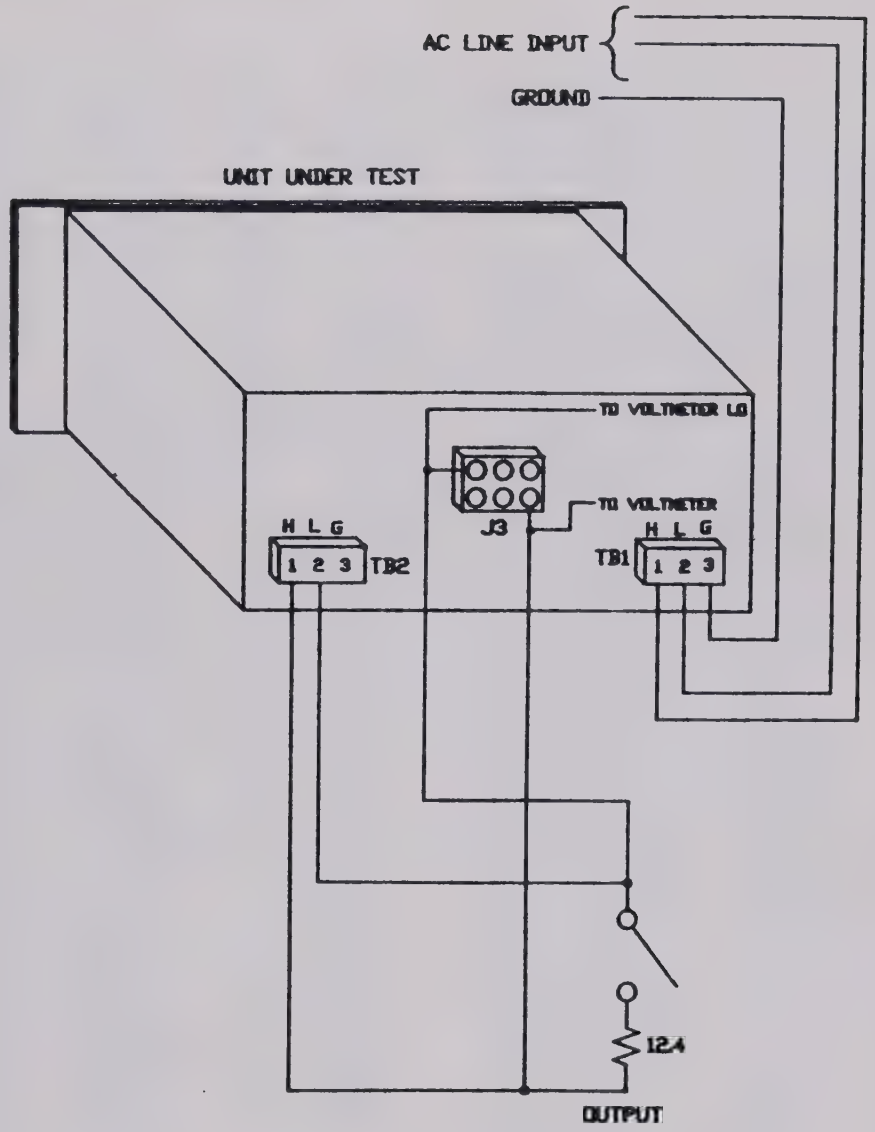


FIGURE 2-2
TEST SETUP

SECTION 3

OPERATION

3-1 GENERAL

The AC Power Source may be programmed from the front panel or through the IEEE-488 remote interface. The rear panel of the AC Power Source holds the power input and output terminals remote sense connector, system interface connector, IEEE-488 interface connector and the chassis ground stud.

3-2 FRONT PANEL CONTROLS

All front panel controls are shown in Figure 3-1. A voltmeter is located at the left side of the front panel. The voltmeter shows the output volt status.

A circuit breaker is on the left side of the front panel. The circuit breaker is used to switch power to the unit. When the circuit breaker is switched ON, the amber indicator lamp above the circuit breaker illuminates.

The front panel has a subpanel with a keypad, remote lamp, LCD display and a viewing angle adjustment. The 20-key keypad allows the power source to be manually programmed at the front panel. The knob labeled VIEW ANGLE many be turned to adjust the contrast of the front panel display. The remote lamp illuminates when the AC Power Source has been addressed through the IEEE-488 interface (GPIB).

3-3 FRONT PANEL INDICATORS

A lamp is located just above the input circuit breaker. It illuminates when power is applied and the circuit breaker is on.

An analog voltmeter, that indicates from 0 to 300 volts, shows the actual output voltage.

An OVERTEMP lamp illuminates when the temperature of the power amplifier heatsink has surpassed a maximum set level. When the fault is detected, the output is disabled and must be reprogrammed after the overtemperature condition has been eliminated.

An OVERLOAD lamp illuminates when the output current exceeds the programmed current limit value. The output will default to 5.0 volts and the output relay will open shortly after the condition occurs.

A HIGH RANGE lamp illuminates when the AC Power Source is programmed to the high voltage range.

An LCD digital display shows the numeric value of all programmed output parameters. It also shows all error messages and measured values.

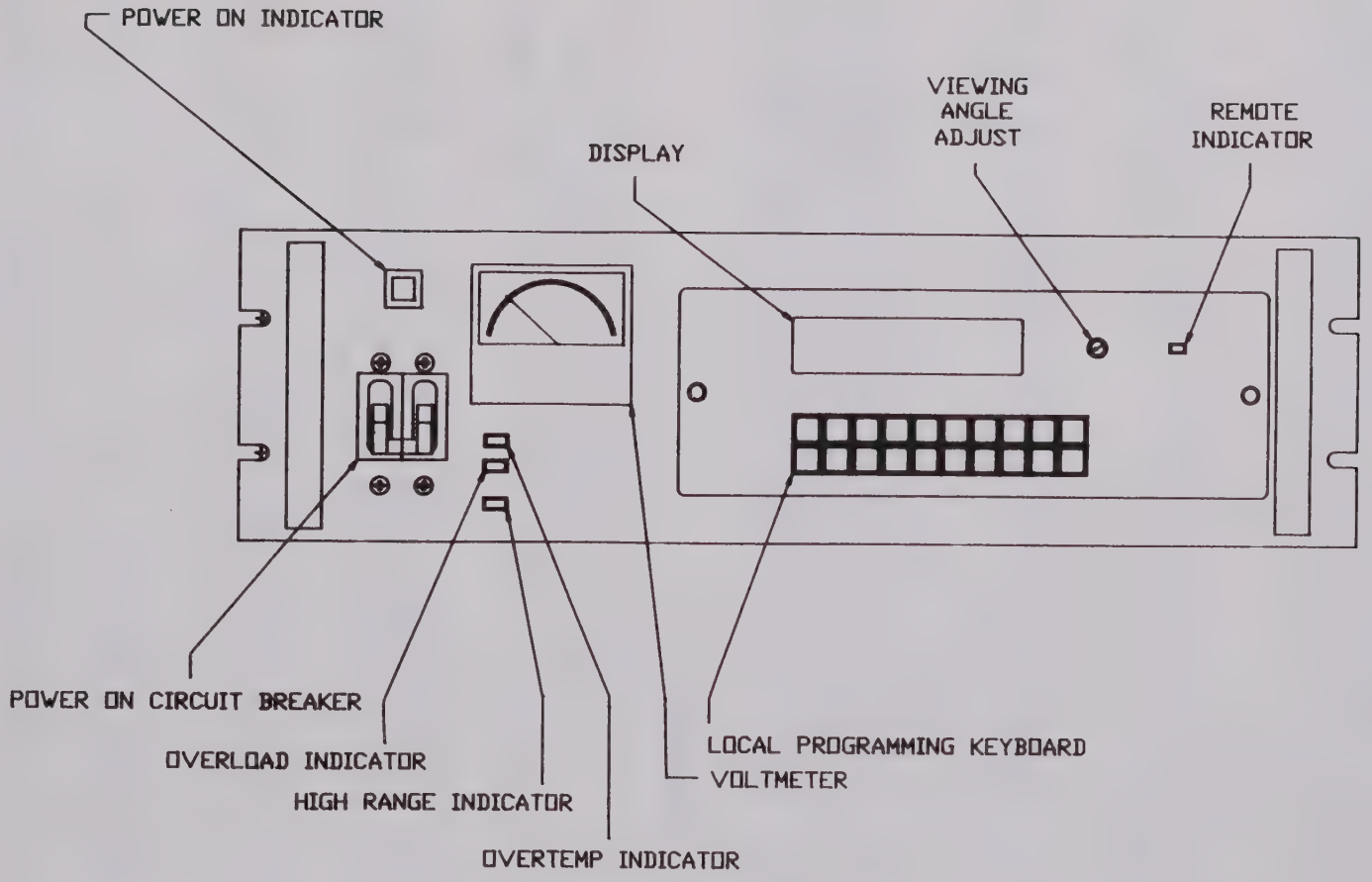


FIGURE 3-1
FRONT PANEL CONTROLS AND INDICATORS

A REMOTE lamp illuminates when the AC Power Source has been addressed from the IEEE-488 interface.

3-4 REAR PANEL CONNECTIONS

TB1 is the terminal block for the three input wire. Terminals 1 and 2 connect to the High and Low input. Terminal 3 is the chassis connection which should be connected to the input main ground.

TB2 is the power output terminal block. Refer to Table 3-1 for identification of the TB1 and TB2 terminals.

TB 1	DESCRIPTION	TB2	DESCRIPTION
1	Input HI	1	Output HI
2	Input LO	2	Output LO
3	Chassis Ground	3	Chassis Ground

TABLE 3-1

J3 is the remote sense input connector. The remote sense input must be connected to the respective AC Power Source output. If the inputs are not connected, an AMP FAULT error message will be generated. Table 3-2 identifies the pins of connector J3.

J3	DESCRIPTION	CONNECT TO:
1	Do not connect	
2	Do not connect	
3	Sense LO	Output LO
4	Sense HI	Output HI
5	No Connection	- - - - -
6	No Connection	- - - - -

TABLE 3-2

J2 is the IEEE-488 (GPIB) connector.

J5 is the System Interface connector. Table 3-3 identifies the pins of the System Interface connector.

J5	Description
1	Analog Common
2	MR B, Phase B amplifier input signal, not used
3	Analog Common
4	CS B, Phase B current sum, not used
5	CT Common, Current Transformer Common
6	OS B, Oscillator Phase B output, not used
7	Analog Common
8	CL B, Phase B DC current limit, not used
9	RPV, Not used
10	OVR TMP, Overtemperature indication
11	CNF, Output relay
12	FLT C, Phase C current limit fault, not used
13	FLT A, Phase A current limit fault
14	F STB LO, Function Strobe output LO
15	EX SYNC LO, External Sync input LO
16	No connection
17	No connection
18	No connection
19	MR C, Phase C amplifier input signal, not used
20	MR A, Phase A amplifier input signal
21	CS C, Phase C current sum, not used
22	CS A, Phase A current sum
23	OS C, Oscillator Phase C output, not used
24	OS A, Oscillator Phase A output
25	CL C, Phase C DC current limit, not used
26	CL A, Phase A DC current limit
27	D COM, Digital Common
28	RNG HI, High Voltage range
29	REMOTE ON
30	FLT B, Phase B current limit fault, not used
31	F STB HI. Function Strobe output HI
32	EX SYNC HI, External Sync input HI

TABLE 3-3

SYSTEM INTERFACE CONNECTOR (J5)

J5-1 **ANALOG COMMON:** This is the common for all analog signals on the connector.

J5-3 **ANALOG COMMON:** See J5-1.

J5-5 **CT COMMON:**

J5-7 **ANALOG COMMON:** See J5-1.

J5-9 **RPV:** Not used.

J5-10 **$\overline{\text{OVR TMP}}$:** A logic low output to indicate an overtemperature condition.

J5-11 $\overline{\text{CNF}}$: Output relay control indication. This is an output logic line that indicates the state of the output relay. A logic low indicates the output relay is open.

J5-13 **FLT A:** Make no connections.

J5-14 **F STB LO:** Function Strobe Low signal. This is the emitter lead of an optically isolated NPN transistor. The internal power controller turns this transistor on to indicate a change of programmed values.

J5-15 EX SYNC LO: External Sync Low signal. This is the ground return for the TTL external sync input. It connects to the cathode of an LED at the input of an optocoupler. Refer to J5-31.

J5-16 No connection.

J5-17 No connection.

J5-18 No connection.

J5-20 MR A: This is the input signal to the phase A amplifier from the internal oscillator drive signal. Do not make any connection to this pin except for troubleshooting.

J5-22 CS A: Current sum for the phase A output. Make no connection to this pin.

J5-24 OS A: This is the output from the internal phase A oscillator. Use this pin as an input if an oscillator is not installed. 5.0 VRMS on this pin will generate a full-scale output voltage.

J5-26 CL A: A DC level from the oscillator used to set the current limit for phase A.

J5-27 D COM: Digital common.

J5-28 $\overline{\text{RNG HI}}$: A logic output from the internal oscillator to control the Range relays. A logic low on this pin indicates the high voltage range. If the power system is used without an oscillator, this pin is a logic input.

J5-29 **REMOTE ON:** this is a logic input that can be used to remove the programmed output voltage. A logic low on this pin will cause the output voltages to be programmed to 0.0 volts and the output relays to open. A logic high will cause the programmed output voltage to be restored at the output terminals. A contact closure between this pin and J5-27 (D COM) will simulate a logic low state.

J5-31 F STB HI: Function Strobe High signal. This is the collector lead of an optically isolated NPN transistor. The internal power controller turns this transistor on to indicate a change of programmed values. This output will sink more than 2 milliamps to a TTL low logic output level (<.4 volts). The output is an open, collector optocoupler output. A pullup resistor to a + VDC must be connected to J7, pin 31. J7, pin 14, is the common output. Refer to Figure 3-2.

J5-32 EX SYNC HI: External Sync Low signal. This is an input that can be used to synchronize the outputs of the AC Power Source. This input requires a logic high level of at least +4.5 VDC at 1.5 ma. The input should have a duty cycle 50 $\pm$10%. J7-15 is the common input. The External Sync input is optically isolated. It must also be enabled from the SNC screen.

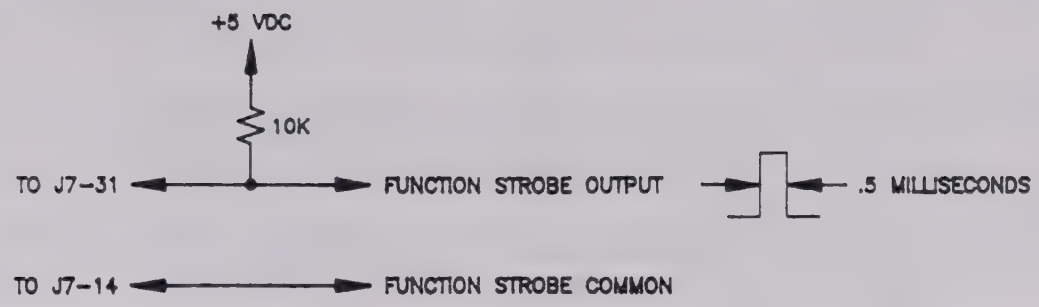


Figure 3-2

FUNCTION STROBE CONNECTIONS

3-5 FRONT PANEL PROGRAMMING

3-5-1 KEYPAD

The front panel keypad is enabled whenever the REMOTE light is not lit. The AC Power Source may be manually programmed by using the keypad while observing the front panel LCD display.

Figure 3-3 shows the front panel keypad. Table 3-4 lists the key and a brief description. While viewing any Output Parameter screen (Ref. Table 3-5), the screens may be viewed in increasing order by depressing the MON key and in decreasing order by depressing the PRG key. While viewing the Measurement Screens, the MON and PRG keys work in a similar fashion. For example, if the AMP parameter screen is displayed, the FRQ screen may be displayed by pressing the MON key one time. The display will be switched back to the AMP screen by pressing the PRG key.

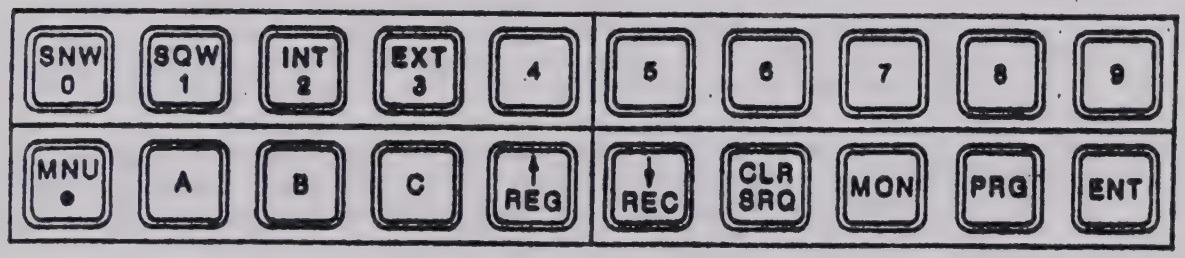


FIGURE 3-3

KEYPAD

KEY	DESCRIPTION
SNW/0	Inputs the value "0" for all output parameters or to select screen "0" when followed by the ENT key. Also used to select the sine wave waveform.
SQW/1	Inputs the value "1" for all output parameters or to select screen "1" when followed by the ENT key. Also used to select the square wave waveform.
INT/2	Inputs the value "2" for all output parameters or to select screen "2" when followed by the ENT key. Also used to select the Internal Synchronize or Internal Clock modes of operation.
EXT/3	Inputs the value "3" for all output parameters or to select screen "3" when followed by the ENT key. Also used to select the External Synchronize or External Clock modes of operation.
4 through 9	Inputs the indicated numeric value for all output parameters or to select the corresponding screen when followed by the ENT KEY.
MNU/.	Selects the Menu screens that show all display screens and the corresponding numeric value. The decimal point function of this key is enabled after any numeric key is depressed.
A	Used to direct any parameter change to phase A. Also used to update any quantity in the display identified as A=.
B	Used to direct any parameter change to phase B. Also used to update any quantity in the display identified as B=.
C	Used to direct any parameter change to phase C. Also used to update any quantity in the display identified as C=.
↑/REG	Used to increment the value in any output parameter screen or calibration screen. Also used to load the program register into any register identified by the preceeding numeric value.
↓/REC	Used to decrement the value in any output parameter screen or calibration screen. Also used to recall the program register identified by the preceeding numeric value.

TABLE 3-4

KEYPAD KEY DESCRIPTION

KEY	DESCRIPTION
CLR/SRQ	Used to clear the numerical inputs for the display screen.
MON	Used to display programmed output parameter values. Used repeatedly, it will cause the display screens of increasing numeric numbers to be displayed.
PRG	Used to program setup values in the Program Register. Used repeatedly, it will cause the display screens of decreasing numeric numbers to be displayed.
ENT	Used to transfer the contents of the program register to the actual output parameters.

TABLE 3-4 (continued)

KEYPAD KEY DESCRIPTION

3-5-2 DISPLAY SCREENS

A display of data on the front panel LCD display is called a screen. There are four types of screens: menu, output parameter, measurement and configuration screens.

Menu screens display the screen abbreviation with its equivalent number. The numeric value for each item in a menu screen is the code that may be used to select the screen. Tables 3-5 through 3-8 show the numeric values for all screens. Without the aid of the tables the MNU key may be used. The menu screens will display only the programmable features that are enabled and their associated screen number.

Table 3-5 shows all of the available Output Parameter screens. While viewing any of the screens, the associated output parameter may be changed from the keyboard.

Table 3-6 shows all of the Measurement screens. When accessing some Measurement screens up to three seconds may be required to display the screen.

Table 3-7 shows all of the screens for calibrating the output and measurement functions. A special code is required to access these screens. Refer to Section 4, Calibration.

Table 3-8 shows all of the Configuration screens. The only value that is user programmable is the IEEE-488 (GPIB) Listen Address.

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
The following are for changing the output:				
1	SNC		INT, EXT	Selects the output to be synchronized to an external input.
*2	CLK		INT, EXT	Selects the external clock mode of operation.
3	WVF		SNW, SQW	Sets the output waveform.
4	RNG		Range limit	Selects the output voltage range. Range limit values of 135 and 270 are standard.
5	AMP		0-RNG limit	Sets the output voltage amplitude.
6	FRQ		45-5000	Sets the output frequency.
8	CRL		0-11.11	Sets the output current limit.
9	RMP A	DLY	0.001-9999	Sets the Delay between ramp steps in seconds. Four decade resolution from 0.001 to 9999 seconds.
		STP		Sets the step size of ramp parameter.
		VAL		Sets the final value of the parameter ramped.
	RMP B	STP		Same as RMPA
		VAL		Same as RMPA

*Optional screen.

NOTE: RMPA and RMPB screens are not accessible until AMP, FRQ, CRL or PHZ are programmed (PRG) but not yet entered (ENT).

TABLE 3-5

OUTPUT PARAMETER SCREEN

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
The following are for measured values.				
11	ELT	H, M, S	Hrs,Min,Sec	Reports the total accumulated run time up to 99,999 hours.
21	VLT		0-300.0	Measures the TRMS output voltage.
22	CUR		0.00-20.00	Measures the TRMS output current in Amps.
23	PWR		0-2000 watts	Measures the True output power.
24	PWF		0-1.000	Measures the power factor of the load.
25	APW		0-2000 VA	Measures the apparent output power.
26	FQM		40-5000	Measures the output frequency in hertz.
27	PZM		0-359.9	Measures the phase angle of the output voltage relative to an external input.

TABLE 3-6

MEASUREMENT SCREENS

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
12	CAL AMP		0-255	Calibrates the programmed output voltage
13	CAL VLT		Actual output voltage	Calibrates the measured voltage to be same as argument.
14	CAL CUR		Actual output current (amps)	Calibrates the measured current to be same as argument.
15	CAL PWR		Actual output power	Calibrates the measured power to be same as argument. The argument is in watts.
20	POF		0-±359.9	Calibrates the programmed output phase angle relative to external reference if used.

TABLE 3-7

CALIBRATION SCREEN

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
16	CFG	A(LSN)	0-30	Sets the IEEE-488 (GPIB) Listen Address.
		B(CFG)	*28	Defines the features enabled for Power Source compatibility.
		C(PHZ)	0	Defines the phase C initial value for power system configuration.
17	ALM	A(RNG)	*0	Code that defines the default voltage range.
		B(LLM)	*135	Defines the upper limit of the lower voltage range.
		C(HLM)	*270	Defines the upper limit of the higher voltage range.
18	FLM	A(FRQ)	*60	Defines the default frequency.
		B(LLM)	*45	Defines the low frequency limit.
		C(HLM)	*5000	Defines the high frequency limit.
19	CLM	A(RNG)	*11.11	Defines the maximum current limit value.
		B(PRS)	*0	Defines the decimal point location for measured power.
		C(CRS)	*2	Defines the decimal point location for measured current.

*NOT USER PROGRAMMABLE. THE VALUES SHOWN ARE FOR A 1500 VA POWER SOURCE. THE VALUES WILL BE DIFFERENT FOR OTHER SOURCES DEPENDING ON REQUIREMENTS.

TABLE 3-8

CONFIGURATION SCREENS

3-5-3 TO PROGRAM OUTPUT VOLTAGE AMPLITUDE (AMP=5)

NOTE

The remote sense lines must be connected to J3 on the rear panel of the AC Power Source. If they are not properly connected an AMP FAULT message will result when the output voltage amplitude is programmed above 5.0 volts. Refer to Figure 2-2.

Select the Amplitude (AMP) screen by entering keystrokes:

5 ENT

The display now shows the AMP parameter screen:

AMP MON A = 5.0

Program the output to 115.5 volts with the keystrokes:

115.5 PRG ENT

Program output to 130.0 volts.

130 PRG ENT

Slowly increase the output amplitude:

↑ (Hold until desired value is obtained.)

3-5-4 TO PROGRAM FREQUENCY (FRQ=6)

Select the Frequency (FRQ) screen by entering the keystrokes:

6 ENT

Program the output to 60.23 hertz:

60.23 PRG ENT

To incrementally increase the output frequency to a desired value:

↑ (Hold until desired frequency is reached.)

3-5-5 TO PROGRAM THE OUTPUT PHASE ANGLE (PHZ=7)

Output phase can be programmed relative to external sync. To program External Sync refer to paragraph 3-5-10. To program output phase to 90 degrees relative to External Sync perform the following sequence:

1. Select the phase (PHZ) screen by entering:

   7 ENT

2. Program phase to 90 degree relative to External Sync by entering:

   90 PRG ENT

3-5-6 TO PROGRAM CURRENT LIMIT (CRL=8)

1. Select the Current Limit screen by entering:

   8 ENT

2. Program the current limit to 5 amps:

   5 PRG ENT

3-5-7 TO PROGRAM VOLTAGE RANGE (RNG=4)

The RNG screen has two purposes; to select a range defined by the range pair selected in the Amplitude Limit (ALM) screen and to select an upper voltage limit less than that specified by the ALM screen, LLM or HLM values. If the range pair 135/270 has been selected in the ALM screen with LLM=135 and HLM=270, the 135 range of the power source will be programmed by the RNG screen for any value of 135 or less. The value programmed will then be the maximum value allowed to be programmed in the Amplitude (AMP) screen.

To select the 270 range and set a program amplitude limit of 250 volts, perform the key sequence below:

   4 ENT 250 PRG ENT

3-5-8 TO PROGRAM RAMP OR STEP FUNCTIONS (RMP=9)

The Ramp (RMP) function allows any programmable parameter (AMP, FRQ, PHZ, CAL or CRL) to be Stepped (STP) with a Delay (DLY) for each step to a final value (VAL). There are three types of programs that may be specified by the RMP screen; a ramp and two types of step programs.

The step function will program the output parameter value specified by a previous screen for the time specified for the DLY value in seconds. The parameter will then return to a final value specified by the VAL value.

The ramp function will step the output parameter value specified by a previous screen with the STP value, the DLY time per step and the final VAL setup in the RMP screen. The ramp will increment if the VAL value is larger than the parameter value. It will decrement if it is less than the parameter value.

NOTE

The DLY, STP or VAL parameters must be specified (A, B or C key depressed) before the number value for the parameter is entered.

When ramping frequency, an error message will result with an attempt to step the frequency with greater resolution than that possible by the initial or final values.

The step program may also be used to generate a dropout to zero volts at any point on the waveform. This type of program is selected by setting the AMP value to zero before setting the DLY and VAL parameters. The point on the waveform at which the dropout occurs is specified by the value in the (PHZ) screen.

The following key sequence will program 130V for 2.5 seconds and then return to a final value of 115V.

1. Select the AMP screen and enable 130 volts to be programmed:

   5 ENT 130 PRG (*)

2. Select the RMP screen, program a DLY of 2.5, a final VAL of 115 volts and run the program:

   9 ENT A 2.5 PRG C 115 PRG ENT

The next example will illustrate a ramp program. The following sequence will ramp the frequency from 60 hertz to 400 hertz in .1 hertz steps with a delay (DLY) for each step of .003 seconds. The total time for this ramp will be = [(VAL-FRQ)/STP]DLY or 10.2 seconds.

1. Select the FRQ screen and set the starting frequency of 60 Hz:

   6 ENT 60 PRG

2. Select the RMP screen, set a DLY of .003, set the STP of .1, set the final VAL of 400 and run the program:

   9 ENT A 0.003 PRG B 0.1 PRG C 400 PRG ENT

(*) If the ENT key is depressed at this point, the AMP would be programmed to and remain at 130 volts.

The following program will illustrate a dropout to zero volts. The program will drop the amplitude to zero volt at 90 degrees for .002 seconds and return to 115 volts.

1. Select the AMP screen and program phase A to 115 volts:

   5 ENT 115 PRG ENT

2. Select the PHZ screen and program to 90:

   7 ENT 90 PRG ENT

3. Select the AMP screen and program the dropout voltage to zero volt:

   5 ENT 0 PRG

4. Select the RMP screen. Set a delay of .002 seconds and a return value of 115 volts:

   9 ENT A 0.002 PRG C 115 PRG

5. Execute the program by depressing the ENT key.

Two output parameters may be ramped simultaneously. The parameter programmed just prior to entering the RMP A screen will be the independent parameter and will be identified in that screen. The parameter loaded prior to the independent parameter will be the dependent parameter.

The following example will ramp frequency from 360 to 440 Hz at a rate of .2 Hz per .2 second, while each .2 Hz step causes the amplitude to go from 10 volts to 210 volts in .5 volt steps.

1. Select the AMP screen (dependent parameter) and program the start to 10 volts:

   5 ENT 10 PRG

2. Select the FRQ screen (independent parameter) and program the start frequency of 360 Hz:

   6 ENT 360 PRG

3. Select the RMPA screen and program the independent ramp parameters of STP = .2, and DLY = .2 and VAL = 440:

   9 ENT A 0.2 PRG B 0.2 PRG C 440 PRG

4. Select the RMPB screen and program the dependent (AMP) ramp parameters of STP = .5:

   10 ENT B 0.5 PRG

5. Start the program by pressing the ENT key.

The final value of the dependent parameter, AMP, will be determined by the number of steps of the independent parameter and the STP value, .5V specified in RMP B.

FINAL VALUE = INITIAL VALUE + (RMP B STP) (NO. STEPS)
NO. STEPS = (DEP. PAR.) (FINAL VALUE - INITIAL VALUE)/STEP SIZE

In this example:

NO. STEPS = (440 - 360)/.2 = 400

FINAL AMP VALUE = 10 + .5 X 400 = 210 Volts

If the final value exceeds the RNG value, an error message will be generated.

NOTE

Any ramp may be terminated at any time by depressing the ENT key.

3-5-9 TO PROGRAM THE OUTPUT WAVEFORM (WVF=3)

The waveform selection is an option for the AC Power Source. If the screen cannot be selected the option is not enabled.

The WVF screen displays the type of waveform selected, sine wave (SNW) or square wave (SQW), for each of the three outputs. To program a square wave, depress the SQW or any odd number key followed by the PRG key and ENT key.

To program the output to square wave:

SQW PRG ENT

To select the sine wave waveform depress the SNW or any even number key followed by the key sequence described above.

3-5-10 TO PROGRAM EXTERNAL SYNCHRONIZATION (SNC=1)

The SNC screen displays whether the external or internal SNC mode of operation has been selected. While viewing this screen to select the external SNC mode depress the EXT key followed by the PRG and ENT key:

Example: EXT PRG ENT

While operating in the EXT SNC mode, the FRQ screen will display the frequency of the External Sync signal. The signal must be between 45 Hz and 5000 Hz.

NOTE

When viewing the SNC, CLK or WVF screens the MON or PRG keys must be used to sequence to another screen. The MNU key can also be used to return to the menu then followed by any screen selection.

To return to the internal SNC mode of operation, depress the INT key or any even numeric key followed by the PRG and ENT key while viewing the SNC screen.

Example: INT PRG ENT

If the External Sync signal is not between 45 Hz and 5000 Hz, the message will be 'EXT SYNC ERROR'.

In the EXT SNC mode the value on the PHZ screen represents the angle of the output leading the External Sync input. If the zero degree point of the power source does not match the zero degree point of the External Sync input, the POF screen may be used for calibration. Select the POF screen and enter a value for calibration.

3-5-11 TO PROGRAM THE EXTERNAL CLOCK (CLK=2)

The clock selection is an option for the AC Power Source. The CLK screen displays whether the AC Power Source is operating in the external (EXT) or internal (INT) CLK mode of operation. While viewing this screen to select the EXT CLK mode, depress the EXT key followed by the PRG and ENT key:

Example: EXT PRG ENT

NOTE

Before selecting the External Clock mode, ensure that the AC Power Source containing the oscillator has the proper clock and lock signals applied to the BNC connectors at the rear panel. . Failure to have the proper clock and lock signals when the EXT CLK mode of operation is selected may result in an AMP FAULT error message. No output from the AC Power Source will be available.

To return to the internal (INT) CLK mode of operation, depress the INT or any even numeric key followed by the PRG and ENT key while viewing the CLK screen.

Example: INT PRG ENT

3-5-12 TO PROGRAM REGISTERS AND RAMPS

The AC Power Source has 16 registers that can be used to store setups. All of the data stored in the registers will be retained during power-down. Register operation may be chained to another register by adding the REC and register number to any setup sequence. The REC and REG keys are used for register operations. Any of the previous examples may be stored in a register by adding the extra step of entering the register number followed by depressing the PRG key. This extra step must be entered before the last ENT keystroke.

The following program will program 135 volts and 60 hertz on the output for 10 seconds before reducing the output to 115 volts and store the test in register 0.

1. Select the FRQ screen and program 60 hertz:

   6 ENT 60 PRG

2. Select the AMP screen and program 135 volts:

   5 ENT 135 PRG

3. Select the RMP screen and program DLY = 10 and VAL = 115

   9 ENT A 10 PRG C 115 PRG

4. Store the program in register 0:

   0 REG ENT

To recall and perform the register operation, simply enter the register number followed by depressing the REC and ENT keys.

3-5-13 REGISTER LINKING

Any number of registers may be linked together by using the REC key prior to loading the register operation.

The following program will ramp the voltage from 115 volts and 60 hertz to 135 volts with .1 volts per 10 millisecond steps, remain at 135 volts for 10 seconds, return to 115 volts at the same rate but at 62 Hz. Store the program in Registers 1 and 2.

1. Select the FRQ screen and program 60 Hz:

   6 ENT 60 PRG

2. Select the AMP screen and program 115 volts:

   5 ENT 115 PRG

3. Select the RMP screen and program DLY = 0.01, STP =0.1 and VAL = 135:

9 ENT A 0.01 PRG B 0.1 PRG C 135 PRG

4. Link this program to Register 2:

2 REC

5. Store this program in Register 1:

1 REG ENT

The second portion of the program will be stored in Register 2.

6. Select the FRQ screen and program 62 Hz:

6 ENT 62 PRG

7. Select the AMP screen and program 135 volts:

5 ENT 135 PRG

8. Select the RMP screen and program DLY = 0.01, STP = 0.1 and VAL = 115:

9. Store this program in Register 2:

2 REG ENT

To initiate the program:

1 REC ENT

3-5-14 TO PROGRAM SIMULTANEOUS RAMPS

Two outputs may be simultaneously ramped or stepped by enabling two parameter screens. The screen first selected will be the dependent parameter. The last parameter screen selected before entering the ramp (RMP) screen is the independent parameter. The independent parameter is used to specify the number of steps in a ramp. Since the dependent parameter has as many steps as the independent parameter, the step (STP) size must be calculated so the dependent parameter will not exceed its maximum value. The following example will specify frequency as the independent parameter and phase as the dependent parameter. Refer to paragraph 3-5-8 for more information.

The following example will ramp frequency from 360 to 440 Hz at a rate of .2 Hz per .2 second, while each .2 Hz step causes the amplitude to go from 10 volts to 210 volts in .5 volt steps.

1. Select the AMP screen and specify the starting voltage of 10 volts:

   5 ENT 10 PRG

2. Select the FRQ screen and specify the starting frequency of 360 Hz.

   6 ENT 360 PRG

3. Select the RMP A screen and specify the ramp parameters of the independent parameter, FRQ, of DLY = .2 seconds, STP = .2 Hz and VAL = 440 Hz:

   9 ENT A 0.2 PRG B 0.2 PRG C 440 PRG

4. Select the RMP B screen and specify the ramp parameter of the dependent parameter, AMP, of STP = .5 volts:

   10 ENT B 0.5 PRG

5. At this point the program may be executed by depressing the ENT key or stored in a register.

3-5-15 ERROR MESSAGES

Table 3-9 shows all of the possible error messages displayed on the front panel display. The cause of the error message is also shown.

ERROR MESSAGE	CAUSE
AMP FAULT	Incorrect sense line connection. Overload on indicated output.
TEMP FAULT	Amplifier overtemperature
CPU MEMORY FAULT	CPU failed self-test
DMA OVERFLOW	Remote message greater than 256 bytes.
EXT SYNC ERROR	No external sync input at System Interface connector. Signal is not between Low Frequency Limit and High Frequency Limit.
BUS LOCAL ERROR	Remote message sent while AC Power Source is in local.
SYNTAX ERROR	Incorrect syntax received from IEEE-488 Remote Interface
AMP RANGE ERROR	Attempt to program AMP value greater than RNG value.
FRQ RANGE ERROR	Attempt to program FRQ less than Low Frequency Limit or greater than High Frequency Limit.
CRL RANGE ERROR	Attempt to program CRL greater than 11.11.
RNG RANGE ERROR	Attempt to program RNG greater than 270.0 or other optional high voltage range.
RMPA RANGE ERROR	Attempt to program STP, DLY or VAL greater than the maximum.
DIV ERROR	Consult factory.
OVERFLOW ERROR	Consult factory.

FRONT PANEL DISPLAY ERROR MESSAGES

TABLE 3-9

3-5-16 TO MEASURE THE OUTPUT

Seven measurement screens display the output voltage, current, power, apparent power, power factor phase and frequency.

While viewing any measurement screen, except ELT, any other measurement screen may be displayed by repeatedly depressing either the MON or PRG key. The screen may also be displayed by entering its equivalent screen number followed by depressing the ENT key. Refer to Table 3-6 for all measurement screen numbers.

3-5-17 TO MEASURE THE OUTPUT VOLTAGE (VLT=21)

The voltage screen displays the actual TRMS output voltage with 0.1 volt resolution. This voltage is the voltage at the Remote Sense connector of the AC Power Source. To access the voltage screen, depress the keys:

21 ENT

3-5-18 TO MEASURE THE OUTPUT CURRENT (CUR=22)

The current screen displays the actual TRMS load current. The resolution is 0.01 amp for the AC Power Source.

3-5-19 TO MEASURE THE OUTPUT POWER (PWR=23)

The power screen displays the actual true power delivered to the load. The resolution is 1 watt.

3-5-20 TO MEASURE THE OUTPUT POWER FACTOR (PWF=24)

This screen displays the power factor from 0 to 1.000 with 0.001 resolution. The PWF screen will read unity for loads less than 10 digits of apparent power on the Apparent Power (APW) screen. When this screen is displayed after another screen, it takes approximately two seconds to update the screen.

3-5-21 TO MEASURE THE OUTPUT APPARENT POWER (APW=25)

This screen is accessed by its screen number, 25. It displays VOLT-AMPERES with a resolution of 1 VA.

3-5-22 TO MEASURE THE OUTPUT FREQUENCY (FQM=26)

This screen is accessed by its screen number, 26. It displays the output frequency with a resolution of 0.01 Hz, 0.1 Hz or 1 Hz up to 99.99 Hz, 999.9 Hz or 5000 Hz, respectively.

3-5-23 TO MEASURE THE OUTPUT PHASE ANGLE (PZM=27)

This screen is accessed by its screen number, 27. It displays phase A relative to an external synchronizing input. The resolution is 0.1 degree.

3-5-24 ELAPSED TIME (ELT =11)

This screen displays the total run time accumulated on the AC Power Source up to 99,999 hours.

H = Hours M = Minutes S = Seconds

3-6 REMOTE CONTROL

Remote programming through the IEEE-488 Interface (GPIB) consists of sending the unit address and the proper ASCII alphanumeric characters to identify the parameter and the numerical value or other argument. The description of the abbreviations for GPIB messages used in this section are listed in Table 3-10. These abbreviations must not be confused with the device dependent abbreviations used to describe the AC Power Source operating parameters (ex. FRQ=Frequency, etc.).

3-6-1 UNIT ADDRESS

This is the A value (LSN) set in the CFG screen. The Unit Address 0 through 30 corresponds to the HEX value 20 through 3E. Refer to Table 3-11 for the equivalent HEX, Binary, ASCII and Decimal equivalents. The Unit Address is set at the factory to 1 but may be changed by selecting the CFG Configuration screen and setting a new value.

To select the CFG screen repeatedly depress the MNU key until menu screen #1 is displayed as illustrated below:

```
SNC = 01        CLK = 02
WVF = 03        RNG = 04
```

Enter the key sequence: 959 ENT

Repeatedly depress the MNU key until the menu screen #5 is displayed as illustrated below:

```
CFG = 16        ALM = 17
FLM = 18        CLM = 19
```

Enter the key sequence: 16 ENT

The CFG screen will now be displayed. Depress the A key to display the present Unit Address. It may be changed to any value from 0 to 30 and will be stored in non-volatile memory. The new unit address will not be updated until power is shut off and reapplied to the power system.

The following key sequence will change the unit address to 16:

16 PRG ENT

TABLE 3-10

COMMONLY USED GPIB ABBREVIATIONS

ABBREVIATION	DEFINITION
ATN	Attention. A logic line on the GPIB asserted only by the controller to indicate the data on the bus represents a bus message.
CR	An ASCII carriage return.
DCL	Device Clear. A universal bus message to initialize all instruments to their power-on states.
END	End. A message conveyed when a talker uses the EOI line with the last data byte of a data string.
EOI	End Or identify. A logic line on the GPIB asserted by a talker to indicate the last byte of a data string.
EOS	End Of String. A delimiter message that consists of a data byte(s) to indicate the end of a data string.
GET	Group Execute Trigger. A GPIB message to trigger an addressed instrument.
GTL	Go To Local. A GPIB message to put an addressed instrument in the local control mode.
IFC	Interface Clear. A logic line on the GPIB asserted by the controller to clear all interfaces (ex., default to unlisten and untalk).
LF	An ASCII line feed.
REN	Remote Enable. A logic line on the GPIB asserted by the controller. REN enables an instrument to go to remote when addressed.
SDC	Selected Device Clear. A GPIB message to initialize an addressed instrument to its Power-on state.

TABLE 3-11

UNIT ADDRESS GROUP

LISTEN ADDRESS	HEX	BINARY						DECIMAL	ASCII
			A5	A4	A3	A2	A1		
0	20	001	0	0	0	0	0	32	SP
1	21	001	0	0	0	0	1	33	!
2	22	001	0	0	0	1	0	34	"
3	23	001	0	0	0	1	1	35	#
4	24	001	0	0	1	0	0	36	$
5	25	001	0	0	1	0	1	37	%
6	26	001	0	0	1	1	0	38	&
7	27	001	0	0	1	1	1	39	'
8	28	001	0	1	0	0	0	40	(
9	29	001	0	1	0	0	1	41	)
10	2A	001	0	1	0	1	0	42	*
11	2B	001	0	1	0	1	1	43	+
12	2C	001	0	1	1	0	0	44	,
13	2D	001	0	1	1	0	1	45	-
14	2E	001	0	1	1	1	0	46	.
15	2F	001	0	1	1	1	1	47	/
16	30	001	1	0	0	0	0	48	0
17	31	001	1	0	0	0	1	49	1
18	32	001	1	0	0	1	0	50	2
19	33	001	1	0	0	1	1	51	3
20	34	001	1	0	1	0	0	52	4
21	35	001	1	0	1	0	1	53	5
22	36	001	1	0	1	1	0	54	6
23	37	001	1	0	1	1	1	55	7
24	38	001	1	1	0	0	0	56	8
25	39	001	1	1	0	0	1	57	9
26	3A	001	1	1	0	1	0	58	:
27	3B	001	1	1	0	1	1	59	;
28	3C	001	1	1	1	0	0	60	<
29	3D	001	1	1	1	0	1	61	=
30	3E	001	1	1	1	1	0	62	>
UNL	3F	001	1	1	1	1	1	63	?

3-6-2 MESSAGE FORMAT

The message sent to the AC Power Source must have the following format for each parameter:

HHHDXXX----------E±NND

where

H = Three letter mnemonic for each message header (except MODE).

D = Optional header extension (A, B or C) to specify output (ref. Table 3-5 through 3-8)

X = Alpha or numeric argument or # for message header argument.
E = Optional ASCII E for exponent identification
± = Exponent sign
N = Exponent value 0 to ±63
D = Message string delimiter, (CR) (LF) or (LF)

More than one message header with its corresponding argument may be sent in one setup string with a common delimiter.

3-6-3 NUMERIC DATA FIELD

Parameter values may be sent as an unsigned value with a decimal point or a decimal point with an exponent. The phase value may be sent as a signed value.

The Decimal Point for numeric data values may be either sent or inferred. The two following ASCII strings will represent 115 volts.

```
AMP115
AMP115.0
```

There may be any number of digits following the decimal point, not to exceed the 256 byte DMA buffer, but only the Least Significant Digit (LSD) of resolution will be recognized. The LSD for amplitude is tenths of volts. The LSD for frequency is either hundredths or tenths for up to 99.99 Hz or 5000 Hz respectively.

Any parameter's numeric value may be of a mixed form with a decimal point and exponent. The exponent may be a numeric, with or without leading zeros, up to a value of ±63. The following ASCII strings will represent 15 volts:

```
AMP1.15E2
AMP1.15E+2
AMP1.15E+02
AMP1150E-1
```

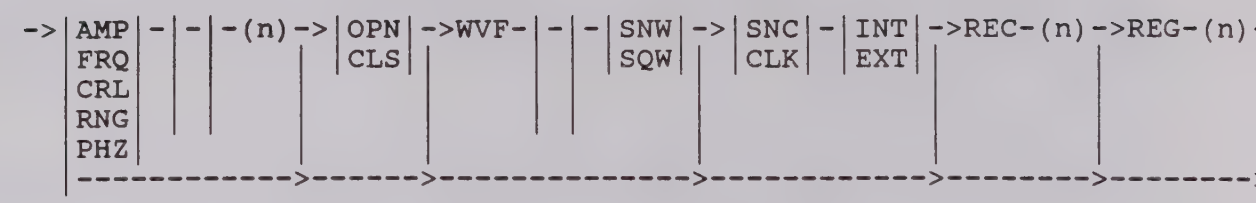
A positive exponent value is represented by either an ASCII "+" or an unsigned value.

3-6-4 PROGRAM HEADERS

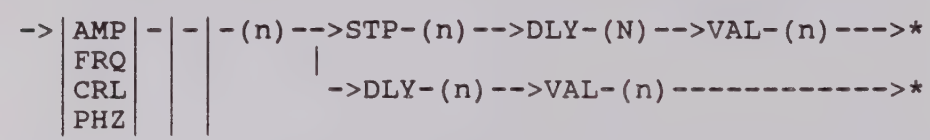
A Program Header is a mnemonic of a series of ASCII characters used to select a function or identify the data it precedes. The header is an abbreviation of the program function it identifies. The header may be followed by a header extension to separately program each segment of the header to different values. See Table 3-12 for the definition of the Program Headers and their related arguments.

Any header that is sent without an argument will cause the front display to show the corresponding screen. Refer the Figure 3-4 for a summary of all possible command sequences.

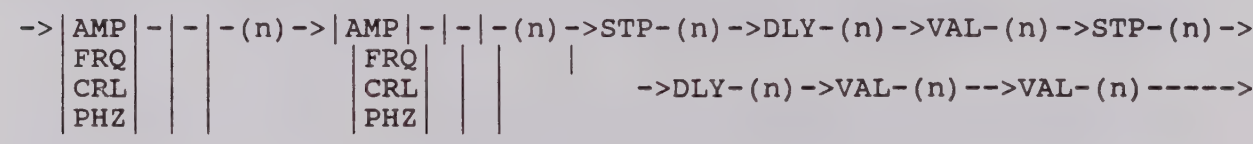
TO_PROGRAM_OUTPUT_PARAMETERS:



TO_RAMP_OR_STEP_ONE_OUTPUT_PARAMETER:



TO_RAMP_OR_STEP_TWO_OUTPUT_PARAMETERS:



TO_REQUEST_TALKING_OF_CALIBRATION_COEFFICIENTS:

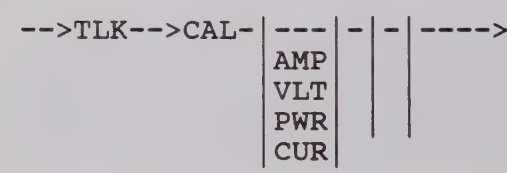
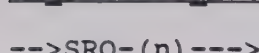


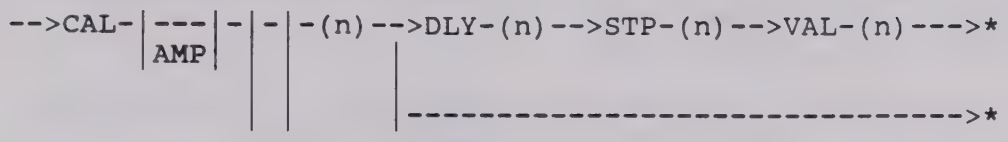
FIGURE 3-4

REMOTE COMMAND SEQUENCES

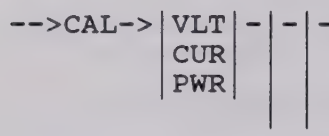
TO SPECIFY THE SERVICE REQUEST INTERRUPT:



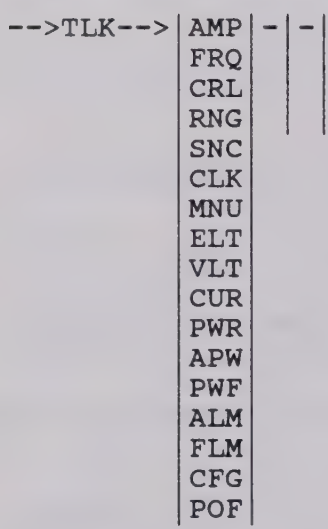
TO CALIBRATE OUTPUT:



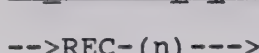
TO CALIBRATE MEASUREMENT:



TO REQUEST TALKING A PROGRAMMED PARAMETER OR MEASURED VALUE:



TO RECALL A REGISTER:



* Represents either an IEEE-488 END or EOS message. The E message may be either an ASCII Carriage Return(CR), Lin Feed(LF) or just LF.

n Represents a numeric value.

FIGURE 3-4 (continued)

REMOTE COMMAND SEQUENCES

TABLE 3-12
PROGRAM HEADERS

HEADER EXTENSION	ARGUMENT	DEFINITION
AMP	# or numeric from 0.0 to RNG value.	Amplitude in volts.
CAL or CAL AMP	# or numeric data from 0.0 to 255	Calibration Coefficient for output voltage.
CAL VLT	Actual voltage	Calibrated measured voltage at remote sense point.
CAL CUR	Actual current	Calibrate measured current.
CAL PWR	Actual power	Calibrate measured power.
CLK	INT,EXT	Clock source
CRL	0 to maximum current	Current limit in amps
DLY	0.000 to 9999 seconds	Delay in seconds used as a ramp parameter
FRQ	45.00 to 5000	Frequency in hertz.
PHZ	0 to 999.9	Output phase angle relative to external sync.
PRG	0 through 15	Load register with preceding data.
REC	0 through 15	Recall register or specify link register if it is preceded by program argument followed by PRG and register number.
REG	0 through 15	Register load
RNG	0.0 to 270 or other optional range value	Amplitude range and limit value in volts.
SNC	INT,EXT	Synchronize

TABLE 3-12 (CONT.)
PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
SRQ		0, 1 or 2	Service Request disable, enable or at completion of program.
STP		From parameter minimum to maximum value	Define step size in ramp.
TLK		Any header	Set up to talk argument value or measured value when addressed to talk.
TRG			Execute (Trigger) set-up parameters on GPIB "GET" message.
VAL		From parameter minimum to maximum value	Final ramp or step value in volts, hertz, amps, degrees, sine wave or square wave.
WVF		SNW,SQW	Waveform
OPN			Open output relay
CLS			Close output relay
VLT			Used with TLK to request measurement of the output voltage.
ELT			Used with TLK to request total accumulated run-time.
CUR			Used with TLK to request measurement of the output load current.

TABLE 3-12 (CONT.)
PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
PWR			Used with TLK to request measurement of the True output power.
APW			Used with TLK to request measurement of the Apparent output power.
PWF			Used with TLK to request measurement of the output power factor.
PZM			Used with TLK to request measurement of the output phase angle relative to external sync only.
FQM			Used with TLK to request measurement of the output frequency.

3-6-5 TO PROGRAM OUTPUT VOLTAGE AMPLITUDE (AMP)

The AMP header is used to identify the amplitude command. The argument is a numeric data field from 0.0 to the limit set by the RNG value. An attempt to program a value higher than this value will generate an error and a SRQ on the GPIB.

The following ASCII strings will program the voltage given in the left column:

0.0 volts	AMP0					
10.5 volts	AMP10.5	or	AMP1.05E1	or	AMP105E-1	
100 volts	AMP100	or	AMP100.0	or	AMP1E2	

3-6-6 TO PROGRAM FREQUENCY (FRQ)

The FRQ header is used to identify the following numeric data as frequency.

The following string will program the frequency to 60.56 Hz.

```
FRQ 60.56
```

3-6-7 TO PROGRAM PHASE ANGLE (PHZ)

The PHZ header is used to identify the following numeric data as phase. The phase output will lead the external sync signal by the value programmed.

The following example will program the output phase angle to 90 degrees relative to external sync if it was operating in the external sync mode.

```
PHZ 90
```

3-6-8 TO PROGRAM CURRENT LIMIT (CRL)

The CRL header is used to identify the Current Limit Command. The argument is a numeric data field from 0.0 to the maximum rated current of the power system.

The following string will program a current limit of 10.5 amps.

```
CRL 10.5
```

3-6-9 TO PROGRAM CALIBRATION (CAL)

The CAL header when used alone or followed by the header AMP is used to calibrate the programmed output voltage. The argument is a relative starting coefficient from 0 to 255 or the ASCII #

symbol. The CAL ramp is terminated with the GPIB message Group Execute Trigger (GET). The CAL header can be used with a Delay (DLY) command to allow the external calibration AC DVM time to settle. Refer to Section 4 for additional information.

A CAL coefficient can be programmed without a ramp by using only the argument with the CAL header.

To program the CAL coefficient to 55 use the following string:

```
CAL55
```

To calibrate the output at 135.0 volts, start the CAL routine with a GPIB GET message with the CAL coefficient starting at 20 and with each step lasting 2 seconds use the following string:

```
AMP135.0 CAL20 DLY2 STP1 VAL255 TRG
```

In this example the output will program to 135.0 and start to change the output by stepping the CAL value after a "GET" message. The ramp will terminate after a second "GET" message.

To calibrate the output at 135 volts and start the ramp with the existing CAL coefficient reducing the output with steps lasting one second:

```
AMP135.0 CAL# DLY1 STP1 VAL0
```

The ramp must be terminated with the bus "GET" message when the external AC calibration DVM indicates the correct voltage.

The CAL header is used with the headers VLT, CUR and PWR to calibrate the respective measurement function. The argument is a numeric value that represents the expected measured value. It should be equal to an external precision TRMS voltmeter, ammeter or power meter.

The following ASCII string will cause the current measurement for the output to measure the value indicated by a TRMS ammeter standard, 10.12 amps:

```
CAL CUR 10.12
```

3-6-10 TO PROGRAM RAMP OR STEP OPERATIONS

The DLY header is used with a parameter that has a numeric argument (ex. AMP, FRQ, PHZ, CRL, CAL) in a single step program. The numeric argument is in seconds with four decade resolution from 0.001 to 9999 seconds.

The STP header with VAL may be used with DLY to completely specify a ramp program.

The following string will first step the voltage to 125 volts for 2.55 seconds and return to 115 volts.

```
AMP 125 DLY 2.55 VAL 115
```

The following string will ramp the voltage from 10 volts to 115 volts with 1.5 volt/.5 sec. steps:

```
AMP 10 DLY .5 STP 1.5 VAL 115
```

When an AMP header with an argument of 0 is used, the waveform will stop and drop to zero volts at the point specified by the PHZ value.

The following ASCII string will stop the waveform at 0 degrees for .01 seconds and return to 115 volts:

```
PHZ 0 AMP 0 DLY .01 VAL 115
```

The STP header is used to identify the following argument numeric value as the increment or decrement value for a FRQ, CRL, AMP, PHZ or CAL ramp.

The following example will ramp the output from 130 volts in 1.5 volt/.5 sec. steps to 10 volts.

```
AMP130 DLY.5 STP1.5 VAL10
```

The header VAL is used to identify the following numeric argument as the final Value of a ramp or step. If the VAL argument is larger than the initial value for the parameter to be ramped, the ramp will increment with step size defined by STP and DLY. With the VAL argument less than the initial value, the ramp will decrement from the initial parameter.

A ramp or step operation can be stopped at anytime by the GPIB message Group Execute Trigger (GET).

The following example will decrement the output amplitude from 120 in .1 volt/.2 sec steps to 100 volts after a Device Trigger.

```
AMP 120 DLY.2 STP.1 VAL100 TRG
```

The following example will ramp the Frequency from 400 to 5000 Hz at a rate of 10 Hz per second and the Amplitude from 5 volts in increments of .5 volts per step:

```
RNG270 AMP5 FRQ400 STP10 DLY1 VAL5000 STP.5
```

A GPIB Service Request will be generated at the end of a ramp if SRQ2 is included in the setup string.

3-6-11 TO PROGRAM A REGISTER (REG)

The REG header is used to load the register specified by the following numeric data with the preceding data. The numeric value is from 0 to 15. The PRG header is identical to the REG header and is included to standardize other AC power controllers.

The following example will load a ramp program that will step the voltage from 10 to 115 volts with 1 volt/.5 sec steps at 400 Hz into register 0.

```
FRQ400 AMP10 DLY.5 STP1 VAL115 REG0
```

3-6-12 TO RECALL A REGISTER (REC)

The REC header is used to recall previously loaded data from a register identified by the following register number (0 to 15).

The following example recalls and outputs the parameters stored in register 0 by an example in paragraph 3-6-11.

```
REC0
```

The following example recalls the parameters in register 0 and outputs the parameters after the IEEE-488 "GET" message.

```
REC0 TRG
```

The following is an example of register linking. The voltage and frequency is maintained at 115 volts and 60 Hz for 5 seconds and then the program contained in register 0 is recalled and executed. The program is stored in register 1.

```
FRQ60 AMP115 DLY5 VAL115 REC0 REG1
```

The program is initiated by the following ASCII string:

```
REC1
```

3-6-13 TO PROGRAM VOLTAGE RANGE (RNG)

The RNG header is used to select a range. The numeric value following the RNG header will also define the upper limit for the AMP value. The RNG value will select the higher range if the value is greater than the lower range value defined by the ALM screen which is 135 for the standard voltage range. If the range and voltage amplitude are to be programmed by the same data string the RNG header and argument must precede the AMP header or a syntax error will be generated.

The following example will select the 270 range from the 135/270 range pair with an upper amplitude limit of 210 volts.

```
RNG210
```

3-6-14 TO PROGRAM EXTERNAL SYNCHRONIZATION (SNC)

The SNC header is used with the EXT argument to synchronize the output to an external sync input. The output will be phase referenced to the sync input with the displacement equal to the PHZ value.

The following ASCII string will program the output phase to 0 degree relative to the external sync input and select the external sync mode.

```
PHZ0 SNC EXT
```

Sending the ASCII string SNC INT will disable the sync input.

3-6-15 TO PROGRAM EXTERNAL CLOCK (CLK) (optional)

The CLK header has an argument of either EXT or INT. The CLK header with the EXT argument will make one AC Power Source a slave to another system. The slave will operate at the same frequency as the master. Phase of the slave will be related to phase of the master by the PHZ value of the slave.

NOTE

The clock option is only available if the associated power systems have the LK option.

The following ASCII string will enable the CLOCK and LOCK inputs to the associated slave AC Power Source:

```
CLK EXT
```

NOTE

If there is no signal at the CLOCK input at the rear panel of the associated power system, the output will go to zero volts.

The ASCII string CLK INT will return the slave AC Power Source to its programmed frequency.

3-6-16 TO TRIGGER AN OPERATION (TRG)

The TRG header has no argument. When the TRG mnemonic is included in a setup string, it will delay execution of the string until the GPIB Device Trigger message is sent by the bus controller. The TRG header may also be used to trigger register operations by including the TRG header with the string used to recall a register. The following example will delay execution of the program in register 1 until an IEEE-488 Device Trigger is received:

```
REC1 TRG
```

The Trigger mode may also be enabled in the local mode by programming setup parameters without depressing the ENT key. The setup values will then be programmed in the remote mode when the Device Trigger is received.

3-6-17 TO PROGRAM TO OUTPUT WAVEFORM (WVF) (Optional)

The header WVF is used to identify the following argument as the Sine Wave (SNW) or Square Wave (SQW) function of the Waveform.

The following example will program the output to the square wave function.

```
WVF SQW
```

The following example will program the output to the sine wave function:

```
WVF SNW
```

3-6-18 TO OPEN (OPN) AND CLOSE (CLS) THE OUTPUT RELAY

The OPN and CLS headers open and close the output relays in the power source. There is no argument associated with these headers. When the OPN or CLS headers is received the output voltage will be programmed to zero volts for 50 milliseconds before the output relays open or close.

3-6-19 TO TALK (TLK) MEASURED AND PROGRAMMED DATA

The TLK header will setup the AC Power Source to talk data. The TLK header will setup the AC Power Source to report a programmed output parameter if the program header is the argument for the TLK header.

To setup the AC Power Source to report a measured value, attach a measurement header to the TLK argument. The measurement headers are VLT, CUR, PWR, APW, PWF and FQM.

The following string will setup the AC Power Source to measure the power output when it is talk addressed:

```
TLK PWR A
```

All arguments for the TLK header are shown in Table 3-13. Table 3-14 shows an example response for all TLK arguments with no A, B or C extension.

TABLE 3-13

TLK ARGUMENTS

ARGUMENT	EXTENSION	DATA REPORTED	DEFINITION
ALM	A	0000	Default voltage range code
	B	*135.0	Low voltage range.
	C	*270.0	High Voltage range
AMP		0 to 270.0	Programmed voltage Amplitude value in volts.
APW		0 to 2000	Output VA
CFG	A	0 to 30	IEEE-488 Listen address
	B	* 28	Configuration code
	C	* 0	Phase C initial value - output configured.
CLM	A	11.11	Defines the maximum current per phase
	B	0	Defines the power decimal point
	C	2	Defines the current decimal point
CRL		0 to 11.11	Programmed output current limit
CUR	A, B, C	0.00 to 20.00	Measured output current
ELT	A	0000 to 9999	Total accumulated hours (H)
	B	00 to 59	Accumulated minutes (M)
	C	00 to 59	Accumulated seconds (S)
FLM	A	60	Default frequency
	B	45	Low frequency limit
	C	5000	High frequency limit
FQM	None	45.00 to 5000	Measured output frequency
FRQ	None	45.00 to 5000	Programmed frequency

(*) Standard values shown. Values will be different for other ranges, output power and options.

TABLE 3-13 (continued)

TLK ARGUMENTS

ARGUMENT	EXTENSION	DATA REPORTED	DEFINITION
CLK	None	INT or EXT	Programmed clock source
SNC	None	INT or EXT	Programmed external sync mode
WVF		INT or EXT	Programmed waveform
PHZ		0.0 to 359.9	Programmed output phase angle
PWR		0 to 2000	Output watts
PZM		0.0 to 359.9	Measured phase A angle relative to external sync.
REG	0 to 15	Contents of Reg	Talk contents of register
RNG	None	0 to 270.0	Programmed range and limit
SRQ	None	0, 1 or 2	Programmed SRQ status
VLT		0.0 to 270.0	Measured output voltage

TABLE 3-14

EXAMPLE TALK RESPONSE

ASCII STRING SENT		RESPONSE AFTER ADDRESSED TO TALK		
TLK	ALM	ALMA0000	B135.0	C270.0
TLK	AMP	AMPA005.0		
TLK	APW	APWA1003		
TLK	CFG	CFGA0001	B0028	C0120
TLK	CRL	CRLA11.11		
TLK	CUR	CURA06.14		
TLK	ELT	ELTH0147	M0051	S0033
TLK	FLM	FLMA0060	B0045	C0550
TLK	FQM	FQM59.97		
TLK	FRQ	FRQ60.00		
TLK	CLK	CLK INT (*)		
TLK	SNC	SNC INT		
TLK	PHZ	PHZA000.0		
TLK	PWF	PWFA1.000		
TLK	PWR	PWRA0.737		
TLK	PZM	PZMA000.0		
TLK	REG0	ACTUAL CONTENTS OF REGISTER 0		
TLK	RNG	RNGA 135.0		
TLK	VLT	VLTA120.1		
TLK	WVF	WVFA SNW		

(*) If function is not enabled a Syntax Error message will be generated.

3-6-20 TO TALK THE MEASURED OUTPUT VOLTAGE (TLK VLT)

VLT may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Source to measure the output voltage with 0.1 volt resolution.

When VLT is used as a header in a string with no argument, it will cause the front panel to display the measured output voltage.

3-6-21 TO TALK THE MEASURED OUTPUT CURRENT (TLK CUR)

CUR may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Source to measure the output current in amps with 0.01 amp resolution.

When CUR is used as a header in a string with no argument, it will cause the front panel to display the output current.

3-6-22 TO TALK THE MEASURED OUTPUT POWER (TLK PWR)

PWR may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Source to measure the output power in watts with 1 watt resolution.

When PWR is used as a header in a string with no argument, it will cause the front panel to display the output power.

3-6-23 TO TALK THE MEASURED OUTPUT POWER FACTOR (TLK PWF)

PWF may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Source to measure the output power factor from 0 to 1.000.

When PWF is used as a header in a string with no argument, it will cause the front panel to display the output power factor.

3-6-24 TO TALK THE MEASURED OUTPUT APPARENT POWER (TLK APW)

APW may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Source to measure the Apparent Power output in VA with 1 VA resolution.

When APW is used as a header in a string with no argument, it will cause the front panel to display the measured output Apparent Power.

3-6-25 TO TALK THE MEASURED OUTPUT FREQUENCY (TLK FQM)

FQM may be used as an argument to the header TLK. When FQM is used as an argument, it will set up the AC Power Source to measure the output frequency in hertz.

When FQM is used as a header, it will cause the front panel to display the measured output frequency.

3-6-26 TO TALK THE MEASURED OUTPUT PHASE ANGLE (TLK PZM)

PZM may be used as an argument for the header TLK. When used as an argument, PZM will set up the AC Power Source to measure the phase angle of phase A relative to external sync. The measurement is made at the Remote Sense terminals. Phase A will always be reported as 000.0 degrees unless the AC Power Source is operating in the external sync mode.

When PZM is used as a header, it will cause the front panel to display the phase measurement screen.

3-6-27 MESSAGE SEPARATORS

A complete message consists of a header and an argument. Since more than one message can be sent in a setup string, message separators included in the string between the message will make it more readable to the human operator. Three message separators are recognized: the comma (,), semicolon (;) and a space. Since these separators are ignored, they may be dispersed throughout a setup string.

The following are two examples of ASCII strings with separators:

```
PHZA90;FRQ60;AMP115

CRL,90;FRQ50;AMP,120
```

3-6-28 SERVICE REQUEST

After power-up the GPIB Service Request (SRQ) will be generated after any error (example. syntax, output fault, etc.). This SRQ output can be inhibited by the SRQ header followed by the single digit "0". The SRQ can be reenabled by the SRQ header followed by 1. Sending SRQ2 causes an SRQ to be generated after the execution of a setup string. The setup string can be of any type: ramp, calibration, etc.

The following example disables GPIB SRQ.

```
SRQ0
```

3-6-29 SERIAL POLL STATUS BYTE

Once the bus controller has detected the SRQ, it must determine the instrument needing service by the Serial Poll. During the polling routine the instrument needing service will return a Status Byte (STB) greater than decimal 63. The Status Byte values for various faults are given in Table 3-15.

3-6-30 END OF STRING

The End of String (EOS) delimiter recognized by the AC Power Source is the ASCII Line Feed (LF). Carriage Return (CR) followed by Line Feed may also be used for EOS. The End or Identify (EIO) IEEE-488 message END will also be recognized. The END message is sent by setting the IEEE-488 End or Identify line true with the last data byte.

3-6-31 ERROR MESSAGES

Table 3-15 shows all of the possible error messages that can be generated by the AC Power Source. These messages will also be displayed on the front panel of the AC Power Source.

3-6-32 GROUP EXECUTE TRIGGER

The trigger mode is enabled when the mnemonic TRG is added to a setup string. The trigger command may be inserted anywhere in the string. When the mnemonic is detected, it will delay execution of the new setup values until the GPIB Device Trigger is sent by the bus controller.

A GPIB Device Trigger will also terminate a programmed ramp or other program.

The following setup string will recall the values from register 9 and delay execution until the GET message is received. (Note: GET is the abbreviation for the GPIB Group Execute Trigger message and does not represent a series of ASCII characters. (See Table 3-10).

```
REC9TRG
```

TABLE 3-15

STATUS BYTE VALUES

STATUS BYTE SRQ = 1	REPORTED MESSAGE	CAUSE
64	AMP A FAULT	Overload or sense line fault
72	TEMP A FAULT	Amplifier overtemperature
90	RNG RANGE ERROR	RNG value greater than 270.0
91	AMP RANGE ERROR	AMP value greater than RNG value
92	FRQ RANGE ERROR	FRQ value is less than 45 or greater than 5000.
93	PHZ RANGE ERROR	PHZ value greater than ±999.0
94	CRL RANGE ERROR	CRL value greater than maximum value
95	RMPA RANGE ERROR	DLY, STP or VAL values wrong
96	SYNTAX ERROR	Wrong string SYNTAX
97	BUS LOCAL ERROR	Remote message sent while in local mode
98	EXT SYNC ERROR	No external sync input or signal not between 45 and 5000 Hz
99	CPU MEMORY FAULT	CPU failed self-test
100	DMA OVERFLOW ERROR	Remote message greater than 256 bytes
101	CAL RANGE ERROR	Unable to calibrate output
127		The response after SRQ2 is included in a setup string and the execution of the string has been completed.
<64	STA OK	No problems

TABLE 3-16
HP SERIES 80 CONTROLLER STATEMENTS

STATEMENT	DESCRIPTION
CLEAR 7	Universally sets all instruments to their power-on states by sending the GPIB message DCL
CLEAR 701	Sets only instrument with listen address "1" to its power-on state by sending the GPIB message SDC.
LOCAL 7	Universally sets all instruments into their local control mode by deasserting REN.
LOCAL 701	Sets only instrument with listen address "1" to its local control mode by sending the GTL message.
REMOTE 7	Sets REN true.
REMOTE 701	Sets instrument with listen address "1" to remote.
ABORTIO 7	Clears all instrument interfaces to unlisten and untalk by toggling IFC.
RESUME 7	Sets ATN false.
OUTPUT 701; "AMP"; V	Sends the data string AMP followed by the numerical value of variable V to the instrument with listen address "1".
STATUS 7,1;A	This statement reads the SR1 register of the series 80 controller for the interrupt cause. This statement is necessary to clear the Service Request flag in the controller.
ENABLE INTR 7; 8	This statement allows the series 80 controller program to be interrupted when a GPIB instrument generates an SRQ.
ON INTR 7 GOSUB100	This statement will cause the program to go to an interrupt subroutine at 100.
TRIGGER 7	This statement triggers all addressed instruments by sending the GET message.
TRIGGER 701	This statement will trigger only the instrument with listen address "1" by sending the GET message.
A=SPOLL (7)	Sets variable A equal to the decimal value of the Status Byte of an instrument previously addressed to talk.
A=SPOLL (701)	Sets variable A equal to the decimal value of the Status Byte of the instrument with listen address "1".

3-6-32 HEWLETT PACKARD SERIES 80 PROGRAM EXAMPLES

For the following program examples, the listen address is "1" and the controller interface is select code "7".

Table 3-16 lists some of the Series 80 Controller statements that may be useful in programming the AC Power Source on the GPIB. For additional statements and their descriptions refer to the Hewlett Packard I/O Programming Guide for the Series 80 Computer.

The following program will step the program voltage from 0 volt to 130 volts in .1 volt steps:

```
10 REMOTE 7
20 FOR V=0 TO 130 STEP .1
30 OUTPUT 701; "AMP"; V
40 NEXT V
50 END
```

The following program will load the parameters of 115 volts and 400 hertz. The Model AC Power Source will output the parameters only after the K1 special function key of the Series 80 Controller is depressed to send the GET message.

```
10 REMOTE 701
20 OUTPUT 701 ; "AMP115 FRQ 400 TRG"
30 ENABLE KBD 32+64 ! ENABLE PAUSE AND SPECIAL FUNCTION KEYS
40 ON KEY # 1 GOTO 100 ! USE KEY K1 FOR DEVICE TRIGGER
50 GOTO 40

100 TRIGGER 701
110 END
```

The program example for SRQ uses the statements STATUS, ON INTR, ENABLE INTR, AND SPOLL.

The STATUS statement in line 20 is necessary to clear the Controller status register from any possible previous Service Request (SRQ) interrupts. The HP I/O Programming Manual is not clear on the use of the STATUS statement but it must be used after every SRQ and before enabling or reenabling the SRQ interrupt to prevent false SRQ indication. Line 30 causes the program to go to the interrupt subroutine at line 100.

The ENABLE INTR statement in line 40 enables the SRQ to generate an interrupt. A setup string in line 60 causes an SRQ to be generated. The SRQ interrupt subroutine is between lines 100 and 150.

The STATUS statement in line 120 clears the SRQ.

Line 130 generates a Status Byte from the AC Power Source with listen/talk address "1".

```
10  REMOTE 701 ! PUT INSTRUMENT#1 INTO REMOTE
20 STATUS 7,1,;Z! READ STATUS TO CLEAR HP SERIES 80 STATUS
    REGISTER.
30  ON INTR 7 GOSUB 100! ON SRQ GO TO ROUTINE AT LINE 100.
40  ENABLE INTR 7;8! ENABLE HP SERIES 80 FOR SRQ INTERRUPT.
50  ! THE FOLLOWING SETUP STRING WILL GENERATE AN SRQ AFTER COM-
    PLETION.
60  OUTPUT 701; AMP105 DLY10 VAL115 SRQ2.
70  WAIT 20000!
80  DISP "SETUP STRING DIDN'T GENERATE AN SRQ".
90  END
100 ! SERVICE REQUEST FOR DEVICE 1
110 ! USE SERIAL POLL TO DETERMINE STATUS BYTE
120 STATUS 7,1;Z ! READ STATUS TO CLEAR SRQ
130 A=SPOLL (701)
```

3-7 REMOTE OPERATION WITH MATE CIIL

When the AC Power Source is configured to operate with CIIL as the principal language, the alternate language is APE. Refer to Figure 3-4 for information on the APE program syntax. Using CIIL, the 1501L will accept OP codes, the noun ACS (AC SIGNAL) and noun modifiers to program the operating parameters of voltage, frequency, phase and current limit in a setup string. In addition, a number of OP codes cause the AC Power Source to perform a specific task such as reset and confidence testing. Figure 3-5 is a summary of the CIIL program syntax.

3-7-1 CIIL ELEMENTS

The Control Interface Intermediate Language (CIIL) elements are:

OP-CODES:	FNC, SET, SRX, SRN, CLS, OPN, RST, CNF, IST, INX, FTH, STA, GAL
NOUN:	ACS
NOUN MODIFIERS:	VOLT, FREQ, PANG, CURL, SYNI, POWR, APOW, CURR, TRSC
CHANNEL DESIGNATORS	:CH00, :CH01

The only noun recognized by the 1501L is ACS for AC Signal. The only non-operational code (no-op) in a string is an ASCII space. Numeric expressions may be represented by explicit decimal values (e.g., 115.0) or exponential values (e.g., 0.115E3). The exponent field may be either a one-digit or two-digit form (e.g., E1 or E01) signed or unsigned with a range from E-24 to E+24.

STIMULUS STRING

```
                                                          *
FNC-->-ACS->-->:CH00->--->SET->------>VOLT->---<value>-<CR><LF>
             ->:CH01->  ->SRX->      ->FREQ->
                        ->SRN->      ->PANG->
                                     ->CURL->
                                     ->SYNI->

*NOTE:  There is no value for SET SYNI


RST---->ACS---->---->:CH00->----<CR><LF>
                   ->:CH01->


-->---->CLS->_____>:CH00->----<CR><LF>
      ->OPN->     ->:CH01->
```

GENERAL CIIL STRINGS

```
-->---->GAL->---><CR><LF>
      ->CNF->
      ->IST->
      ->STA->
```

SENSOR STRINGS

```
    FNC---->ACS-->---->VOLT->--------->:CH00->------<CR><LF>
    RST--             ->FREQ->        ->:CH01->
                      ->PANG->
                      ->CURR->
                      ->APOW->
                      ->POWR->

    ------>INX->------>VOLT->------<CR><LF>
         ->FTH->      ->FREQ->
                      ->PANG->
                      ->CURR->
                      ->APOW->
                      ->POWR->
```

FIGURE 3-5

CIIL PROGRAM SYNTAX

3-7-2 Channel Designators

The channel designator consists of a colon (:) followed by the syntax CH and a single-digit or two-digit channel number. The general form for the channel designator is CHnn and may be any of the following;

:CH00 Designates output.
:CH01 Designates output.

Channel designators and their applicable noun modifiers are listed in Table 3-17.

3-7-3 OP-Codes

Each of the OP-codes listed is described in following paragraphs.

3-7-3-1 FNC

All set-up strings must begin with OP-code FNC followed by the noun ACS, and the channel designator :CHnn (e.g., FNC ACS :CH01).

3-7-3-2 Set

The SET (set-up) OP-code must be sent when a characteristic included in the output string is to be programmed. The noun modifiers that may follow the SET OP-code are VOLT, FREQ, SYNI, CURL, TRSC and PANG. A SET OP-code is always followed by a noun modifier. A SET string has the following string elements:

FNC ACS :CHnn SET<NOUN-MOD><NUMERIC> <CR> <LF>

An example of a setup string where the output is set to 115.0 volts as follows:

FNC ACS :CH01 SET VOLT 115.0 <CR><LF>

Note that all strings end with ASCII <CR><LF>. The AC Power Source is configured to recognize this series of ASCII characters as indicating end-of-string (EOS).

Table 3-17 Channel Designators and Noun Modifiers.

CHANNEL DESIGNATOR	MODIFIER	FUNCTION
:CH00	VOLT	Set output amplitude.
:CH01	VOLT	Set output amplitude.
:CH00	FREQ	Set Frequency.
:CH01	FREQ	Set Frequency.
:CH00	PANG	Syntax error with :CH00.
:CH01	PANG	Set output phase angle relative to external sync.
:CH00	CURL	Set output current limit.
:CH01	CURL	Set output current limit.
:CH00	SYNI	Set sync to external signal.
:CH00	POWR	Send power measurement data for output to Bus Controller.
:CH01	POWR	Send power measurement data for output to Bus Controller.
:CH00	APOW	Send apparent power measurement data for output to Bus Controller.
:CH01	APOW	Send apparent power measurement data for output to Bus Controller.
:CH00	CURR	Send output current measurement data for output to Bus Controller.
:CH01	CURR	Send output current measurement data for output to Bus Controller.

3-7-3-3 SRX and SRN OP-Codes

The SRX (set maximum) OP-code sets the maximum value of the programmable noun modifiers VOLT, FREQ, PANG and CURL. It is always accompanied by a noun modifier. An example of setting the maximum output amplitude to 135 volts and the output to 115 volts follows:

FNC ACS :CH00 SRX VOLT 135 SET VOLT 115.0 <CR> <LF>

The SRN OP-code sets the minimum value. For example, to set the minimum value of the output amplitude to 5.0 volts and the output to 20 volts, the following string is transmitted:

FNC ACS :CH00 SRN VOLT 5 SET VOLT 20 <CR> <LF>

3-7-3-4 OPN and CLS

The CLS (Close) OP-code closes the relay between the amplifier outputs and the output connector. The CLS Op-code must be followed by a valid channel designator. (:CH00, :CH01). A programmed amplitude will not be generated at the output of the 1501L until the relay has been closed.

CLS :CH00 <CR> <LF> Closes relay

If an output voltage been programmed prior to the CLS OP-code, the output will appear after CLS has been sent.

The OPN (open) OP-code opens the relay at the power source output. Prior to opening the relay, the output of the AC Power Source is reduced to zero.

```
OPN :CH00 <CR> <LF>   Opens relay
```

3-7-3-5 RST

The RST (reset) OP-code resets the AC Power Source to its default values as follows:

Output Amplitude	5.0 Volts
Frequency	Selected default frequency
Output Phase Angle	0 Degrees*
Sync	Internal
Current Limits	Maximum current of power system
Power Source Relays	Open

*Relative to External Sync.

In addition, all non-catastrophic error messages (SYNTAX and RANGE errors) are cleared. All other error messages are not affected.

OP-code RST must be followed by ACS and any one of the valid channel designators :CH00 and :CH01 (e.g., RST ACS :CH00 <CR> <LF>).

3-7-3-6 CNF and IST

The CNF (confidence) OP-code instructs the 1501L to perform a confidence test of the entire power system. The OP-Code stands by itself. The confidence test flow diagram is shown in Figure 3-6. If confidence testing detects a fault, an appropriate message is transmitted to the Bus Controller on receipt of an STA OP-code (see paragraph 3-7-3-9). The output relays of the power source are opened during confidence testing.

During confidence testing, the AC Power Source generates the following:

Amplitude	115 Volts
Frequency	400 Hz
Current Limit	Maximum and 5% of Maximum

The 1501 compiles a message after the confidence test and the receipt of a STA OP-code. The AC Power Source responds with the appropriate message as shown in Figure 3-6.

The IST (internal self test) OP-code produces the same response described for CNF.

Figure 3-6 Confidence Test Flow Diagram

3-7-3-7 INX

The INX (initialize) OP-code is a request for data from the AC Power Source. A request for the time required to measure the voltage of all phases consists of the following strings:

```
FNC ACS VOLT :CHnn <CR> <LF>
INX VOLT <CR> <LF>
```

The AC Power Source then responds with:

```
<SP> 5 <CR> <LF>
```

The AC Power Source response indicates that 5 seconds will be required to perform the measurement.

Note that the INX OP-code must be preceded by an FNC OP-code string containing the noun modifier for which INX will request data.

3-7-3-8 FTH

The FTH (fetch) OP-code function fetches data from the AC Power Source for the parameter indicated by the noun modifier of the previous string. For example, the following FNC string is first sent:

```
FNC ACS VOLT :CH01 <CR> <LF>
```

Then the measurement value is requested with:

```
FTH VOLT <CR> <LF>
```

Assuming that the output is 115.5 volts, the AC Power Source responds with:

```
<SP> 115.5 <CR> <LF>
```

The FTH OP-code may be repeated for the same FNC noun modifier.

An INX string may be inserted between the two strings as described in 3-7-3-7 if the time to accomplish the measurement is required.

3-7-3-9 STA

The STA (status) OP-code instructs the AC Power Source to transfer its output message to its output buffer. The message is then transmitted to the Bus Controller when the AC Power Source is addressed to talk. Table 3-18 lists all of the possible status messages generated outside of confidence testing. All confidence testing messages are shown in Figure 3-6.

If the power source is operating correctly and the following OP-code is sent:

STA <CR> <LF>

The AC Power Source responds with:

<SP> <CR> <LF>

3-7-3-10 GAL

The GAL (go to alternate language) OP-code instructs the AC Power Source to discontinue use of the CIIL language and start accepting commands in the Abbreviated Plain English (APE) language. While operating in the APE language mode, sending ASCII characters CIIL will return operation to the CIIL language. When power is removed and then restored, the AC Power Source reverts to the native language.

Table 3-18 Non-CNF Status Messages.

CONDITION	DEVICE RESPONSE
Loaded output Fault	F07ACS01 <SP> (DEV): <SP> OUTPUT CH01 VOLT FAULT <CR><LF>
Source Temperature Fault	F0A7CS01 <SP> (DEV): <SP> SOURCE CH01 TEMPERATURE <CR><LF>
Program out of range for VOLT, FREQ, PANG or CURL	F07ACS01 <SP> (MOD): <SP>VOLT/FREQ/PANG/ CURL RANGE ERROR <CR><LF>
Unrecognizable OP-code or missing OP-code	F07ACS01 <SP> (MOD): <SP>SYNTAX ERROR <CR><LF>
Good Status	<SP><CR><LF>

3-7-4 Noun Modifiers

Noun modifiers are a CIIL mnemonic indicating the characteristic of the signal to be described.

Note that other noun modifiers may be included in the above string.

While operating in the external synchronize mode, the AC Power Source tracks the frequency and phase of the external signal. Note that its phase may be offset from the SYNC input. The frequency of the external signal is reported with the following set of strings:

```
(L) FNC ACS FREQ :CH00 <CR> <LF>
(L) INX FREQ <CR> <LF>
(T) <SP> "default time-out value reported"<CR><LF>
(L) FTH FREQ <CR><LF>
(T) <SP> "measured value of external sync frequency reported"
    <CR> <LF>
```

In the above, (L) indicates the AC Power Source is listen addressed and (T) that it is talk addressed. The INX OP-code in the above series of strings may be omitted if the time data is not required.

3-7-4-6 CURR

The CURR (current measurement) noun modifier's single function is to measure current. The strings to initiate the current measurement of the output are as follows:

```
FNC ACS CURR :CH01 <CR> <LF>
FTH CURR <CR> <LF>
```

3-7-4-7 POWR

Noun modifier POWR (power measurement) is included in a string to instruct the AC Power Source to measure the power output of the power source. The strings to initiate the power measurement are as follows:

```
FNC ACS POWR :CH01 <CR> <LF>
FTH POWR <CR> <LF>
```

The response from the AC Power Source is:

```
<SP> 80.5 <CR> <LF>
```

The foregoing assumes an output power of 80.5 watts.

3-7-4-8 APOW

Noun modifier APOW (apparent power measurement) included in a string instructs the AC Power Source to measure the apparent power output of the power source in volt-amperes (VA). The strings to initiate the measurement are as follows:

```
FNC ACS APOW :CH01 <CR> <LF>
FTH APOW <CR> <LF>
```

The response from the AC Power Source is:

<SP> 65.5 <CR> <LF>

The foregoing assumes an apparent output power of 65.5 VA.

3-7-5 NORMAL CONDITION RESPONSES

All normal condition responses of the AC Power Source to requests from the bus controller (either status or measurement requests) begin with an ASCII space <SP>. In the following examples of bus controller/AC Power Source exchange, (L) indicates the AC Power Source is listen addressed and (T) indicates it is talk addressed.

When the AC Power Source is requested to measure one of the parameters identified by a noun modifier (e.g., VOLT), the following strings are sent and received by the bus controller:

(L) FNC ACS VOLT :CH01 <CR> <LF>
(L) INX VOLT <CR> <LF>
(T) <SP> "default time out" <CR> <LF>
(L) FTH VOLT <CR> <LF>
(T) <SP> 115.5 <CR> <LF>

When the AC Power Source receives an STA OP-code after a CNF OP-code, its normal response is an ASCII space <SP>. An example of the strings transmitted and received is:

(L) CNF <CR> <LF>
(L) STA <CR> <LF>
(T) <SP> <CR ><LF>

The AC Power Source accepts the STA OP-code after any string which is sent to it. For example:

(L) FNC ACS :CH00 SET VOLT115 SRX VOLT 135 SRN VOLT5 <CR><LF>
(L) STA
(T) <SP> <CR> <LF>

3-7-6 ABNORMAL CONDITION RESPONSE

When an abnormal condition has been detected by the AC Power Source , its response to the STA OP-code will begin with an ASCII F. The abnormal condition may be in the power source or specifically in the power source controller. In the examples that follow, (MOD) is an abbreviation for MODULE and refers to the power controller; (DEV) is an abbreviation for DEVICE and refers to the power source excluding the power controller. The response string for an abnormal condition is:

F07ACS01 <SP> (DEV): <SP> "message"<CR> <LF>

The status contained in "message" may be similar to the following:

```
OUTPUT CH01 VOLT FAIL
OUTPUT CH01 TEMPERATURE FAIL
CONTROLLER CH01 FREQ FAIL
```

When an STA OP-code is transmitted after any string, the complete abnormal response may be similar to:

```
F07ASC01 <SP> (MOD) : <SP>"message"<CR> <LF>
```

The status contained in "message" may be any of the following for non-CNF messages:

```
SYNTAX ERROR
VOLT RANGE ERROR
FREQ RANGE ERROR
CURL RANGE ERROR
PANG RANGE ERROR
```

The response of the AC Power Source under a short circuit condition is as follows:

```
F07ACS01<SP>(DEV): <SP> OUTPUT CH01 VOLT FAULT <CR> <LF>
```

A setup string can always be followed by another string with the STA OP-code. In the event of a syntax, range or system error, an error message will be returned to the bus controller when the AC Power Source is addressed to talk. The value of the last parameter in a setup string is the one displayed on the front panel of the AC Power Source.

3-7-7 DISCRETE FAULT INTERRUPT

A discrete fault condition is one that would pose a hazard to equipment or personnel. A Discrete Fault Interrupt (DFI) is supplied with the MT power source option. The DFI relay contacts are connected to the BNC connector, J8, on the AC Power Source rear panel. Under normal operating conditions, the DFI relay contacts are open; when a fault is detected, the contacts close. The user may connect any type of indicator or alarm circuit to the DFI connector provided the applied signal is limited to 0.1 amps and 26 volts.

The conditions which will cause the discrete fault interrupt are listed in Table 3-19.

TABLE 3-19

Discrete Fault Interrupt Conditions

FAULT	CONDITION
OVERLOADED OUTPUT	The full rated power capability is exceeded on any phase where programmed output voltage is not maintained.
PROGRAMMABLE CURRENT	The load draws more current than the programmed current limit point on any phase.
OVERTEMPERATURE	Excess heatsink temperature in power supply or output amplifier due to high ambient temperature or internal component failure.
CONTROLLER FAILURE	The AC Power Controller has a CPU failure which is monitored by a watch dog timer.
POWER OFF	Power mains off - input breaker off.

3-7-8 PROGRAM EXAMPLES

Table 3-20 lists some typical CIIL strings. Each one illustrates the versatility in programming which is a feature of the AC Power Source. The strings listed transmit the information with the fewest possible characters. Decimal points need not be included when followed by zeros. Spaces may not be included anywhere in the string.

TABLE 3-20

Sample Programming Strings.

PROGRAM	STRING
The output to 115 volts and current limit to 2 amperes and enable external sync.	FNC ACS :CH00 SET CURL2 SET FREQ400 SET VOLT 115 SET SYNI <CR> <LF>
The output to 100 volts and current limit to 2 amps.	FNC ACS :CH01 SET CURL.2E1 SET FREQ4E2 SET VOLT100 <CR><LF>
To power-up state open relay.	RST ACS :CH00 <CR><LF>
Output phase to 90 degrees.	FNC ACS :CH01 SET PANG90 <CR><LF>
Freq. to 65.23 Hz	FNC ACS :CH00 SET FREQ65.23 <CR><LF>
The output current to 2.5 amps peak current limit.	FNC ACS :CH00 SET CURL2.5 <CR><LF>
Output current limit to 2 amps. peak.	FNC ACS :CH01 SET CURL2 <CR><LF>
Confidence test.	CNF <CR><LF>
For status msg.	STA <CR><LF>
Output relay closed.	CLS :CH00 <CR><LF>
To measure output voltage only of Phase A.	FNC ACS VOLT :CH01 <CR><LF>
Output relay opened.	OPN :CH00 <CR><LF>
To measure Freq.	FNC ACS FREQ :CH00 <CR><LF> FTH FREQ <CR><LF>

TABLE 3-20 (Continued)

Sample Programming Strings.

PROGRAM	STRING
To measure output voltage.	FNC ACS VOLT <CR><LF>
Query time of measurement of voltage.	FNC ACS VOLT <CR><LF> INX VOLT <CR><LF>

SECTION 4

CALIBRATION PROCEDURE

4-1 GENERAL

The calibration is divided into two categories; a periodic and a nonperiodic calibration. The periodic calibration should be performed at a 1 year interval. The nonperiodic calibration should only be performed if the periodic calibration cannot be performed or if an adjustable subassembly is replaced.

The following is a listing of paragraphs that may be performed to fix an indicated problem.

PARAGRAPH	TITLE
4-3-1	OUTPUT VOLTAGE CALIBRATION
	This is a periodic calibration of the output voltage.
4-3-2	MEASUREMENT CALIBRATION
	This is a periodic calibration of the measurements of output voltage, current and power.
4-3-3	REMOTE MEASUREMENT CALIBRATION
4-3-4	REMOTE OUTPUT VOLTAGE CALIBRATION
4-4-1	OUTPUT FREQUENCY CALIBRATION
	This is a nonperiodic calibration of the output frequency.
4-4-2	GAIN ADJUSTMENTS
	These are nonperiodic adjustments of the Current Limit Board, assembly 4005-704. The adjustments may have to be performed for the following reasons: 1. An output amplifier, assembly 4009-404-2, is replaced.
4-3	CURRENT TRANSFORMER ADJUSTMENTS
	These are nonperiodic adjustments. The adjustments are required if it is impossible to perform the current or power measurement calibration (Ref. Paragraph 4-3-2).

4-4 CURRENT LIMIT CALIBRATION

This is a nonperiodic calibration. The calibration is required if the available output current is not equal to the programmed current limit value. The available output current may exceed the programmed value by 10%.

4-2 TEST EQUIPMENT

The following equipment or their equivalents are required to completely test the AC Power Source.

TEST EQUIPMENT FOR PERIODIC CALIBRATION

1. Digital Voltmeter: Fluke Model 8840A (modified per CIC005) or equivalent.

2 10 Amp Current Transformer: Pearson Model 110

3. Resistive Load: 15 to 12.1 ohms, 1500 Watts

ADDITIONAL TEST EQUIPMENT

1. Frequency Counter: Philips PM 6671

4-3 PERIODIC CALIBRATION

The following periodic calibration adjustments should be performed on a 1 year interval.

4-3-1 OUTPUT VOLTAGE CALIBRATION

Apply power to the AC Power Source and allow at least fifteen minutes for temperature stabilization. Program the output to 60 Hz, 135 volts and perform the following steps:

1. Connect the AC voltmeter to the output to be calibrated.

2. Depress the MNU key several times until the first menu screen is displayed as illustrated below.

```
 SNC = 01      *CLK = 02
*WVF = 03       RNG = 04
```

*May not be displayed. Depends on configuration.

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the configuration menu screen is displayed as illustrated below:

```
CFG = 16      ALM = 17
FLM = 18      CLM = 19
```

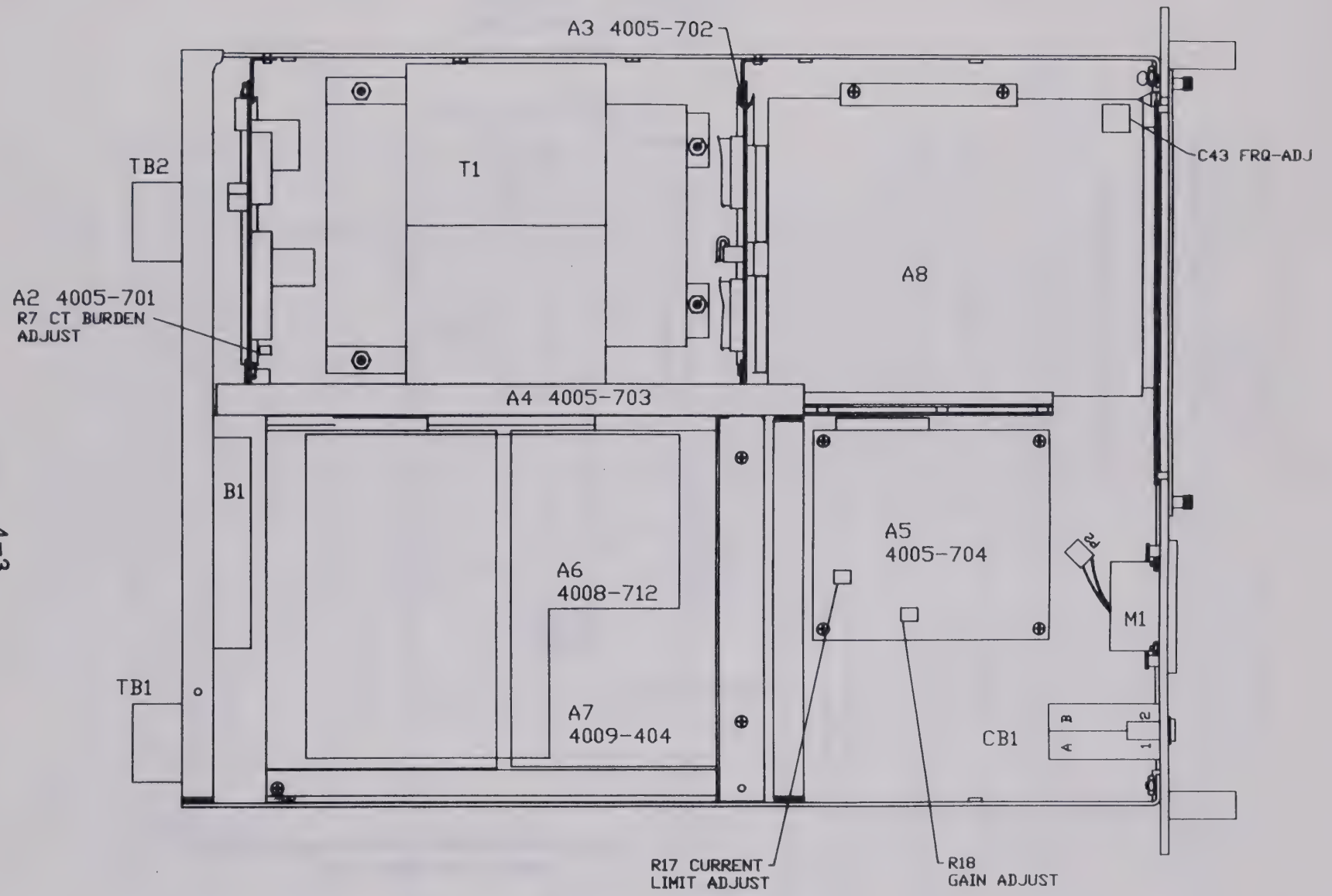


FIGURE 4-1

INTERNAL ADJUSTMENTS AND JUMPER LOCATIONS

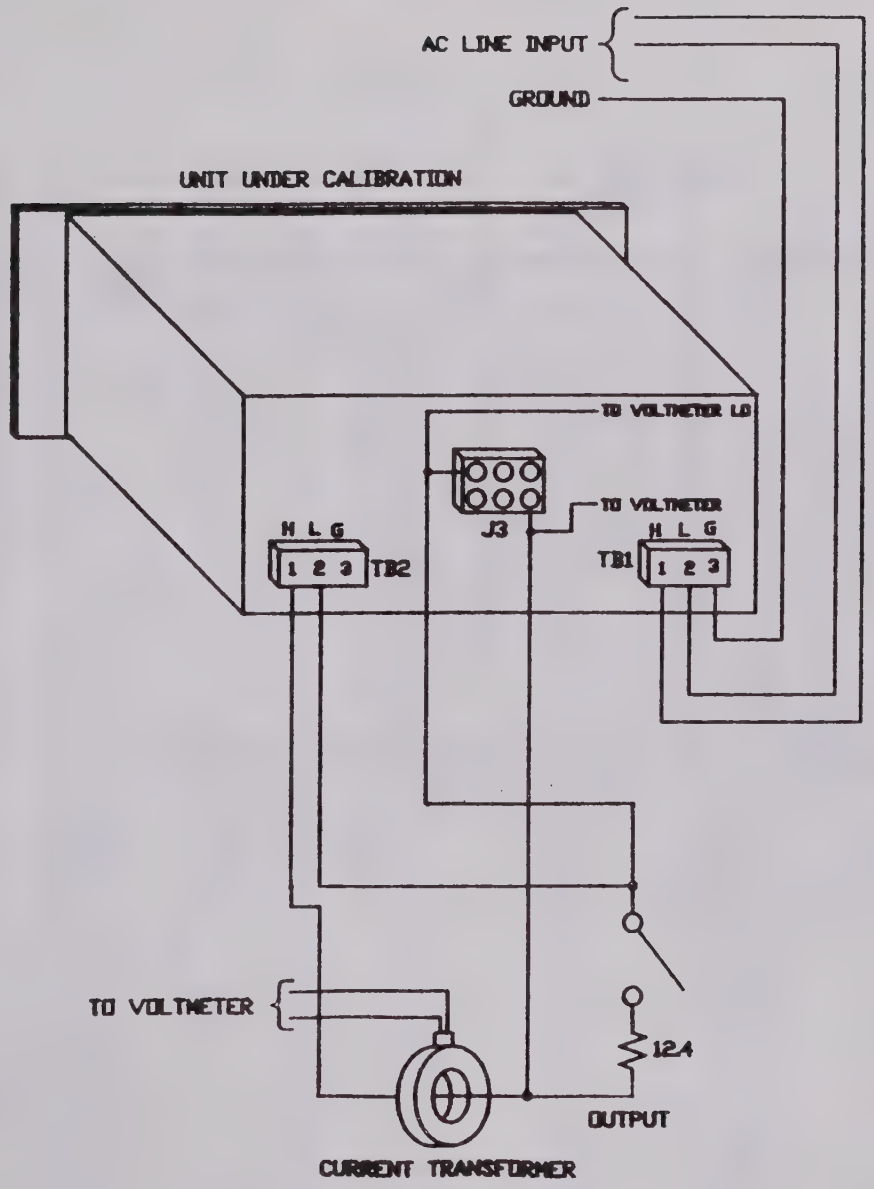


FIGURE 4-2
EQUIPMENT HOOKUP FOR
PERIODIC CALIBRATION

5. Select the CAL screen with the key sequence: 12 ENT

6. If the output voltage is greater than the programmed output, depress and hold the key until the correct output voltage has been reached. The key is used if the output is less than the programmed value.

4-3-2 MEASUREMENT CALIBRATION

For calibration of voltage measurement first perform the output voltage calibration and then perform the followings steps:

1. Remove the load from the AC Power Source and program 60 Hz and 135.0 volts.

2. Depress the MNU key several times until the Menu screen is displayed as illustrated below:

```
 SNC = 01          *CLK = 02
*WVF = 03           RNG = 04
```

*May not be displayed. Depends on configuration.

3. Enter the key sequence: 959 ENT.

4. Depress the MNU key several times until the configuration menu screen is displayed.

```
CFG = 16          ALM = 17
FLM = 18          CLM = 19
```

5. Enter the key sequence 13 ENT to access the CAL VLT screen.

6. Enter the key sequence:

   135 PRG ENT

   After about 5 seconds, the volt measurement function will be calibrated.

For calibration of current measurement perform the following steps:

1. Program 60 Hz and 130.0 volts.

2. If any calibration screen is already displayed, the Current Calibration screen (CAL CUR) may be displayed by repeatedly depressing either the MON or PRG keys and then skip to step 6. If a calibration screen is not displayed, press the MNU key several times until the screen shown below is displayed:

```
 SNC = 01          *CLK = 02
*WVF = 03           RNG = 04
```

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the configuration menu screen is displayed.

5. Enter the key sequence: 14 ENT to access the CAL CUR screen.

6. Apply the 12.3 to 15 ohm load to the output. Measure the output current with the AC Digital Voltmeter and Current Transformer.

7. On the keypad enter the key sequence:

   (Measured output current. Example 11.05) PRG ENT

   After about 5 seconds the current measurement function will be calibrated.

For calibration of power measurement perform the following steps:

1. Program 60 Hz and 145.0 volts.

2. If any calibration screen is already displayed, the Power Calibration screen (CAL PWR) may be displayed by depressing either the MON or PRG keys and then skip to step 6. If a calibration screen is not displayed, depress the MNU key several times until the screen shown below is displayed:

```
 SNC = 01          *CLK = 02
*WVF = 03           RNG = 04
```

3. Enter the key sequence: 959 ENT

4. Depress the MNU key several times until the configuration menu screen is displayed as shown below:

```
CFG = 16          ALM = 17
FLM = 18          CLM = 19
```

5. Enter the key sequence 15 ENT to access the CAL PWR screen.

6. Apply the 12.3 or 15 ohm load to the output. Measure the output current with the AC Digital Voltmeter and Current Transformer. Measure the output voltage from the sense to neutral sense. Multiply the voltage and current values to determine the power value. (Note: The load must be resistive for the correct power value.)

7. On the keypad enter the key sequence:

   (Measured output power) PRG ENT

4-3-3 REMOTE MEASUREMENT CALIBRATION

The measurement function of the AC Power Source may be remotely calibrated. The equipment hookup is the same as before except an IEEE-488 Controller must be used to program the AC Power Source. The values for the VLT, CUR and PWR strings must be derived from the external AC Digital Voltmeters and Current Transformer.

To calibrate the measured voltage, first program the AC Power Source to 135.0 volts and 60 Hz. Send the following calibration string:

CAL VLT (Measured output voltage value

To calibrate the measured current send the following string:

CAL CUR (Measured output current value

To calibrate the measured power value send the following string:

CAL PWR (Measured output power value

4-3-4 REMOTE OUTPUT VOLTAGE CALIBRATION

The ASCII # symbol can be used with remote calibration to greatly reduce the calibration time. The ASCII # is used in place of a calibration coefficient to start the CAL ramp at the existing CAL coefficient and ramp up or down for a VAL argument of 255 or 0 respectively.

The following string will cause the CAL coefficient to ramp down with a delay of .2 seconds per step:

CAL # DLY.2 VAL0

Figure 4-3 is a Flow Diagram for the Remote Calibration program that follows. The program was written in HP Basic for an HP Series 80 computer.

4-4 NONPERIODIC CALIBRATION

If adjustments are required for these nonperiodic calibrations, the top cover of the AC Power Source will have to be removed. A nonperiodic calibration will only be required if a related assembly is replaced or if the performance is out of specification.

4-4-1 OUTPUT FREQUENCY CALIBRATION

Connect the Frequency Counter to the output. Program the output to 135.0 volts and 400.0 Hz. Engage the low-pass filter on the Frequency Counter to obtain the output frequency.

If the Frequency Counter does not indicate 400.000 $\pm$0.001 Hz, adjust C43 for the correct frequency. Refer to Figure 4-1.

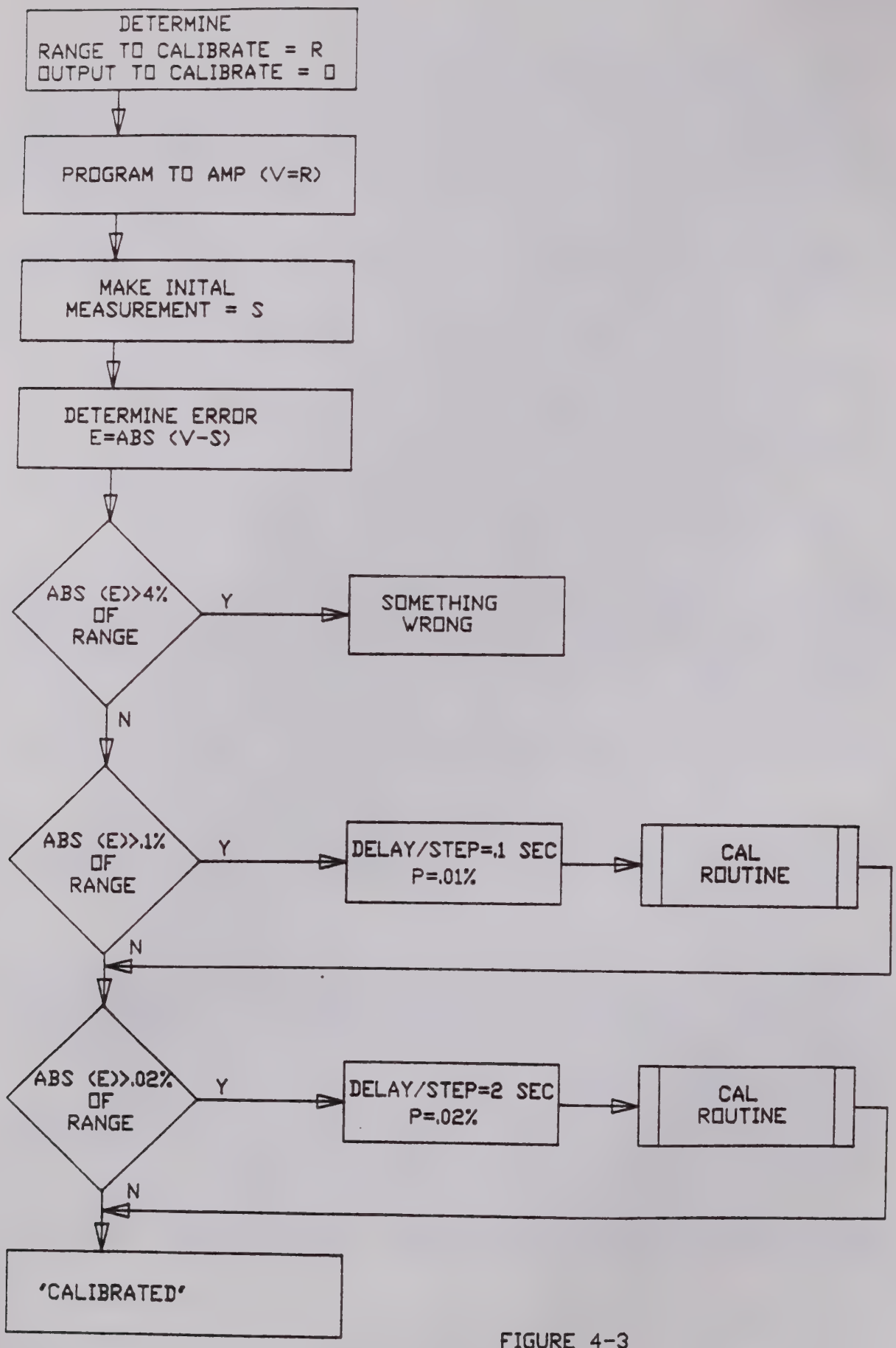


FIGURE 4-3
REMOTE CALIBRATION FLOW DIAGRAM

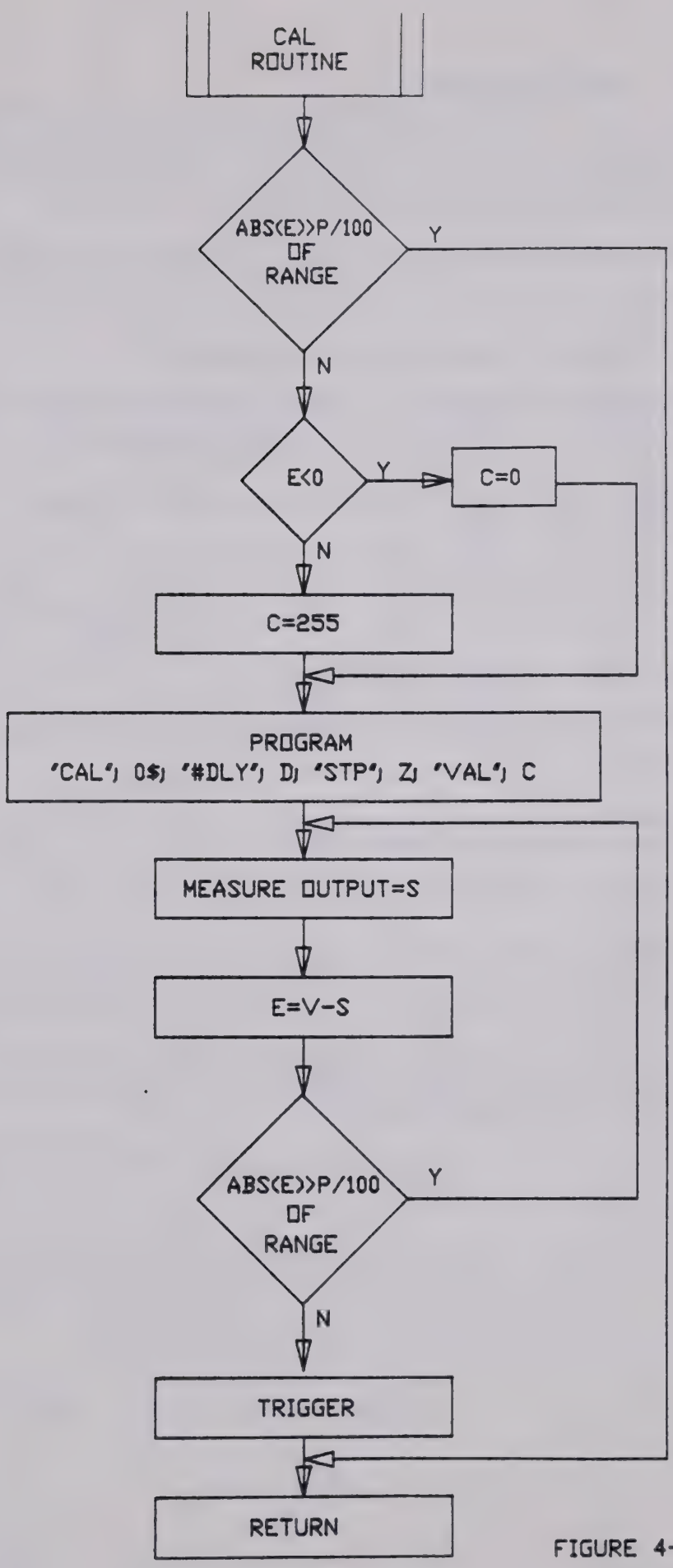


FIGURE 4-3 (CONTINUED)

4-4-2 GAIN ADJUSTMENTS

Remove all loads from the power source output and disconnect the Remote Sense inputs. Connect the AC DVM to the output. Program the output to 100.0V rms and 60 Hz. Hold the ENT to prevent the output from defaulting to its initial condition.

Adjust A5R18 for a DVM indication of 110.0 ±1V rms.

Reconnect the Remote Sense lines.

4-4-3 CURRENT TRANSFORMER ADJUSTMENTS

1. Monitor the output current with the Current Transformer and AC DVM. Measure the output voltage between TP10 (GND) and TP1 on the Current Limit Assembly (5). Refer to Figure 4-1.

2 Turn on the AC input to the AC Power Source. Program 135.0 VRMS and 60 Hz.

3. Apply the resistive load to the output. Adjust R1 on the Range Relay assembly, A2, for the correct voltage at TP10 for the load current: (1 volt = 10 amps). Remove the load.

4-4-4 CURRENT LIMIT CALIBRATION

For the Current Limit Calibration perform the following steps:

1. Program the Current Limit to 9.0 amps.

2. Monitor the output current with the external Current Transformer and AC voltmeter.

3. Program the output voltage to 115 volts and 60 Hz.

4. Apply a load resistor to the output. If the output faults turn A5R17 on the current Limit Assembly clockwise and reprogram 115 volts.

5. Increase the output amplitude slowly until the external AC current transform indicates 10.0 amps. Slowly turn A5R17 on the Current Limit Assembly in a counterclockwise direction until the output faults.

```
10  ! CAL
20  SET TIMEOUT 7;5000 ! SET BUS TIMEOUT TO 5SEC
30  ! CLEAR 7! SEND DEVICE CLEAR
40  CLEAR
50  ABORTIO 7
60  R=135
70  O$="A"
80  DISP "THE AC POWER SYSTEM ADDRESS MUST BE 1 AND "
90  DISP "THE 8506A AC DVM ADDRESS MUST BE 4."
100 DISP "PRESS K1 TO CONTINUE"
110 ON KEY# 1 GOTO 140
120 GOTO 120
130 OFF KEY#
140 DISP "WHAT VOLTAGE RANGE TO CAL 135 OR 270.DEFAULT IS ";R
150 INPUT C$
160 IF C$ <> "" THEN R=VAL (C$)
170 CLEAR
180 IF R=135 THEN DISP "WHAT CAL. VOLTAGE FROM 60 TO 135? THE
    DEFAULT IS 135"
190 IF R=270 THEN DISP "WHAT CAL. VOLTAGE FROM 120 TO 270? THE
    DEFAULT IS 270."
200 INPUT V$
210 IF V$ <> "" THEN V=VAL (V$) ELSE V=R
212 ON TIMEOUT 7 GOTO 2000
214 IF V>125 THEN OUTPUT 704 ;"VAR7,"
216 IF V>40 AND V<= 125 THEN OUTPUT 704 ;"VAR6,"
218 IF V<= 40 THEN OUTPUT 704 ;"VAR5,"
220 DISP "WHICH OUTPUT TO CAL(DEFAULT IS ";O$;")"
230 INPUT P$
240 IF P$ <> "" THEN O$=P$
250 CLEAR
260 DISP "CONNECT THE 8506A AC DVM TO OUTPUT ";O$;"."
270 DISP "PRESS K1 TO CAL."
280 ON KEY# 1 GOTO 300
290 GOTO 290
300 OFF KEY#
310 GOSUB 1000
320 ! OUTPUT CALIBRATED TO WITHIN .02%
330 DISP "OUTPUT ";O$;" CALIBRATED. CAL ANOTHER OUTPUT(Y/N)"
340 INPUT A$
350 IF POS (A$,"Y")=1 THEN GOTO 220
360 LOCAL 7
370 END
500 ! CAL SUBROUTINE
510 ! DETERMINE IF OUTPUT IS WITHIN P% OF R
512 WAIT 2000 ! WAIT 2SEC FOR DVM TO SETTLE
515 GOSUB 800
520 IF ABS (E)<P/100*R THEN GOTO 600
530 ! DETERMINE DIRECTION OF CAL COEFF. RAMP
540 IF E<0 THEN C=0 ELSE C=255
545 ON TIMEOUT 7 GOTO 3000
550 OUTPUT 701 ; "CAL AMP";O$;"#DLY";D;"STP";Z;"VAL";C
560 X=255
562 GOSUB 800
564 IF ABS (E)>ABS (X)+.005 THEN GOTO 590
```

```
566 IF ABS (E)<P/100*R THEN GOTO 590
568 WAIT D*1000
570 X=E
580 GOTO 562
590 TRIGGER 701 ! STOP CAL RAMP WITH DEVICE TRIGGER
600 RETURN
800 ! MEASURE ROUTINE
810 OUTPUT 704 ; "?"
820 ENTER 704 ; 6
830 E=V-S
840 RETURN
1000 ! GEN CAL
1010 ! PROGRAM TO SELECTED RANGE AND AMPLITUDE
1020 OUTPUT 701 ;"FRQ400RNG";R;"AMP";V
1030 WAIT 2000
1040 ON TIMEOUT 7 GOTO 2000
1042 WAIT 2000
1050 GOSUB 800
1070 UF ABS (E)>,04*R THEN GOTO 3000 ! NOT AT EXPECTED OUTPUT
1080 D=1 @ P=.1 @ Z=10 ! DLY=.1SEC FOR CAL TO APPROX. .1%
1090 GOSUB 500
1100 D=1 @ P=.02 @ Z=1 ! DLY=1SEC FOR CAL TO .02%
1110 GOSUB 500
1120 RETURN
2000 DISP "DVM IS INACTIVE. INSURE ADDRESS IS 4."
2010 GOTO 360
3000 DISP "CHECK THAT THE ADDRESS IS 1."
3010 DISP "THE MEASURED OUTPUT IS ",S
3020 GOTO 360
```

SECTION 5

THEORY OF OPERATION

5-1 GENERAL

An explanation of the circuits within the AC Power Source is given in this section. Refer to Figure 5-1 for the block diagram of the AC Power Source.

5-2 OVERALL DESCRIPTION

Input power at the rear panel is routed through the circuit breaker to the high current rectifier and the Power Supply Assembly, A6. The various DC supply outputs then go to the Mother Board, A4, then are directed to other modules.

The Programmable Oscillator Assembly, A8, generates the oscillator waveforms, power source controls and measurement signals. The oscillator assembly is connected to the rest of the power source through the Oscillator Interface Board, A3.

The Amplifier Module, A7, takes its DC supply voltages and input signal from the Mother Board, A4. It produces the high power output for the primary of the output transformer, T1. The output is routed through the Mother Board to the output transformer.

The Range Relay Board is identified as A2. This board assembly configures the secondaries of the output transformers for the correct output voltage range. The output from the AC Power Source is taken from the Range Relay Board.

The Current Limit Board is identified by A5. This board controls the amplifier gain and the programmable current limit.

5-3 INPUT POWER SUPPLY

This assembly is identified as A6. It generates the high power +300 VDC supply.

The input power supply also has circuits that generate the DC voltages identified as ±18V, ±15VSW, +8VSW and +8V.

The ±18V supplies are used for oscillator modules and the Current Limit Board. The +8V supply is used for the oscillator module. The ±15VSW and +8VSW supplies are used for the Amplifier Module.

The input power supply generates a 50 VDC and 15VSW1 from the 300 volt supply. The 50 VDC is used for fan and relay operation, +15VSW1 is used for the gate drive signal in the Amplifier Module.

5-4 CURRENT LIMIT BOARD

The Current Limit Board receives the oscillator signal from the Oscillator Module. The signal is directed to the input of the power amplifier. A gain adjustment is located on the board.

The current limit circuit is also located on the Current Limit Board. The circuit receives a DC signal from the Oscillator Module that is proportional to the current limit value. The DC signal is compared to the output current.

If the output current exceeds the programmed value, an attenuator will limit the output voltage to a value that will cause the AC Power Source to operate at a constant current. If the output current limits the output voltage to 90% of the programmed voltage, an amplitude fault will be generated.

5-5 INDICATOR BOARD

The Indicator Board, A1, has LED indicators for the HI RANGE, OVERTEMP and OVERLOAD conditions.

5-6 RANGE RELAY BOARD

The Range Relay Board has all of the AC Power Source relays. These relays are operated from +50 VDC. The output relay is controlled by the CNF Logic Line. The range relay is controlled by RNG HI line.

There is a current transformer on the Range Relay Board. This transformer generates an AC voltage that is proportional to the output current. A 10 amp load current is represented by 1.00 VAC at the output of the current transformer.

5-7 AMPLIFIER MODULE

The AC Power Source has an amplifier module. The amplifier module operates in a switch mode to obtain high efficiency. The switchmode amplifier operates at 200 KHz.

The Amplifier Module obtains its input signal from the Current Limit Board. A 4.6 VRMS input signal will generate a full scale output voltage at the output of the AC Power Source and 100.0 VRMS on the primary of the output transformer.

The Amplifier Module requires a 300 VDC, $\pm$15VSW, +8VSW and +15VSW1 supplies. The +300 VDC supply comes from the input power supply through a 10 amp fuse on the Power Mother Board.

The Amplifier Module has a thermoswitch mounted on its heatsink. If the heatsink temperature reaches 100 degrees C, a control signal is sent to the Oscillator Module. A logic low on the OVERTEMP control line will cause the error message TEMP FAULT to be generated.

5-8 OSCILLATOR MODULE

The Oscillator Module is identified with the reference designator, A8. The module consists of two printed circuit assemblies. These assemblies are interconnected with a small Mother Board. The Oscillator Display Assembly is mounted to the small Mother Board and is connected to the Oscillator Module with a short ribbon cable. The Oscillator Module is a plug-in module from the AC Power Source front panel.

5-9 CPU/GPIB BOARD

The CPU/GPIB board, A8A3, provides the control and measurement functions of the module. A microprocessor circuit accepts commands from the GPIB or the front panel keyboard. It sends digital programming information to set the output parameters of the power source. Data from measurement circuits are accepted and reported to the display and GPIB. Measurement calibration coefficients are stored in a memory backed up by a battery. The battery has a 10 year life expectancy.

Measurement circuits on the CPU/GPIB board monitor voltage, current, power, frequency, and phase angle. Voltage from the rear panel sense connector is scaled, converted to a DC voltage by a true-rms-converter, and sent to the microprocessor by the analog-to-digital converter.

Current sensed by internal current transformers is scaled, converted to a DC voltage by a true-rms-converter, and sent to the microprocessor by the analog-to-digital converter.

The scaled voltage and current waveforms are applied to the inputs of a multiplier. The multiplier output is filtered to a DC level and digitized by the analog-to-digital converter.

Frequency is computed from the measured time intervals between zero crossings of the output waveform. Phase is computed from the differences of measured zero crossings between the output signal and the external sync signal, if it is enabled.

A digital-to-analog converter on the CPU/GPIB board sets the DC voltages that are used for the programmable current limit function.

5-10 PHASE A/REF BOARD

The Phase A/Ref Board, A8A5, serves several purposes. A programmable clock sets the output frequency of the power source. Digital-to-analog converters program references to set the output amplitude. A sine wave generator creates a 1024 step waveform which is filtered to provide the output oscillator signal. A remote sense amplifier controls the output amplitude.

5-11 DISPLAY MODULE

The Display Board, A8A13, is held to the power source by a small panel and is connected through a short ribbon cable. It holds the 20 button keyboard and a 32 character LCD display. A knob on the board allows the display viewing angle to be adjusted.

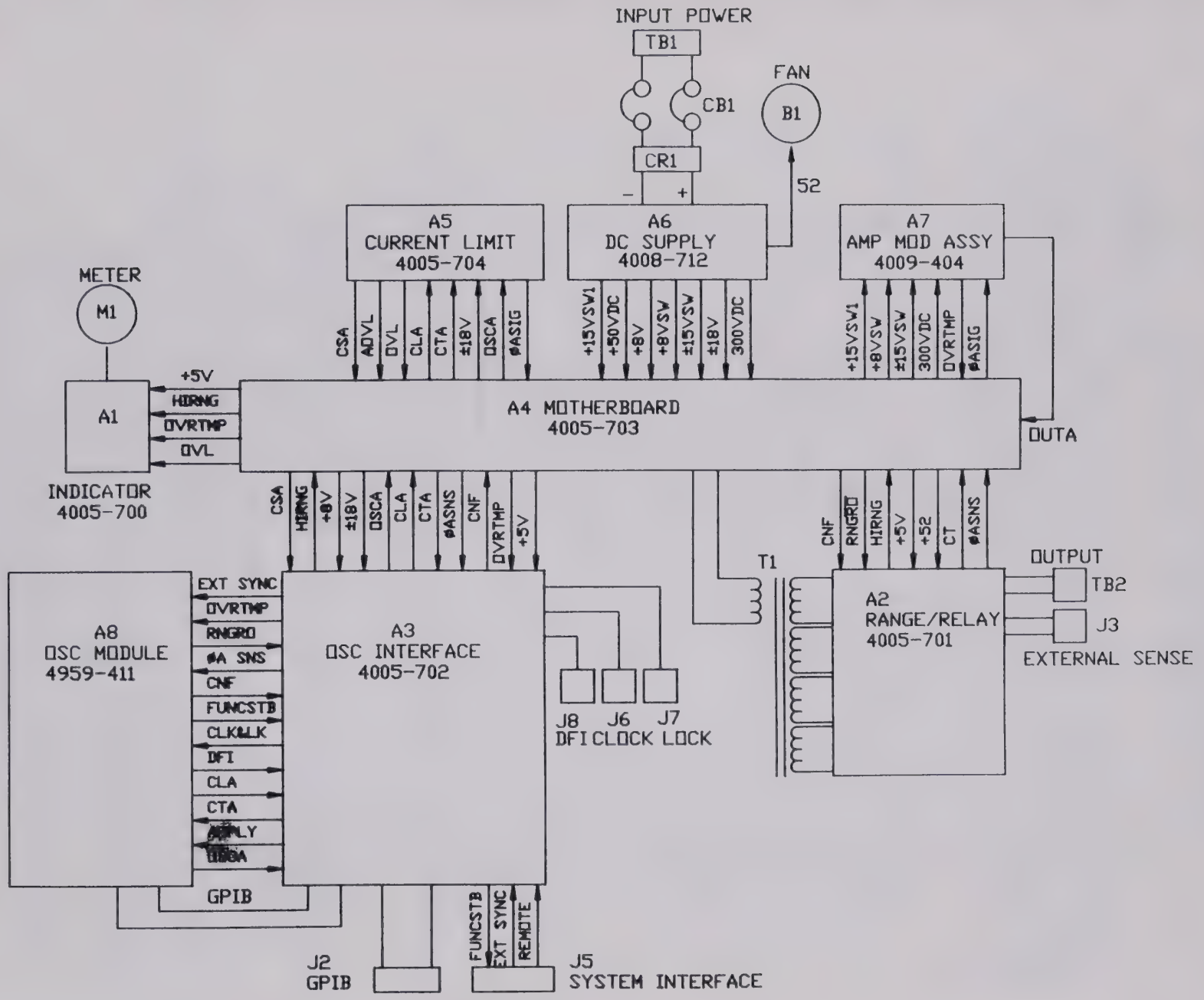


FIGURE 5-1
AC POWER SYSTEM BLOCK DIAGRAM

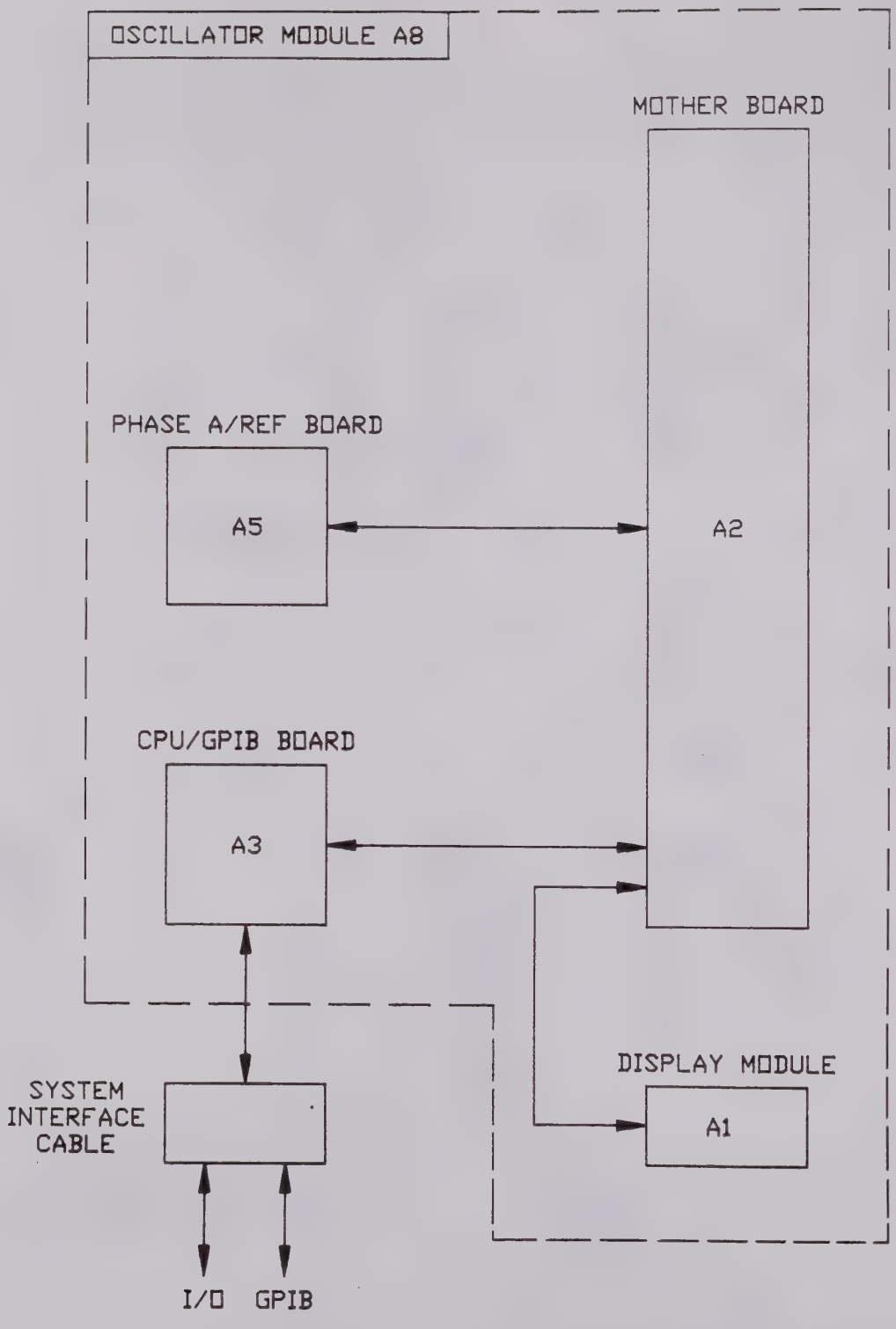


FIGURE 5-2
PROGRAMMABLE OSCILLATOR MODULE

SECTION 6

MAINTENANCE AND TROUBLESHOOTING

6-1 GENERAL

This section describes the suggested maintenance and troubleshooting procedures. Table 6-1 lists the paragraph titles and page numbers for the Troubleshooting section. If the AC Power Source does not appear to function normally, use this section to isolate the problem. If the problem cannot be found using these steps, consult the factory.

TABLE 6-1

PARAGRAPH	PROBLEM	PAGE
6-2	Poor Voltage Accuracy	6-1
6-3	Poor Output Voltage Regulation	6-1
6-4	Overtemperature Lamp On	6-2
6-5	Overload Lamp On	6-2
6-6	Can't Program AC Power Source on GPIB	6-2
6-7	Distorted Output	6-3
6-8	No Output	6-3

6-2 POOR VOLTAGE ACCURACY

If the power source exhibits poor programmed voltage accuracy, the following item may be at fault:

1. The calibration is incorrect.

   SOLUTION: Calibrate the output. Refer to Paragraph 4-3-1.

6-3 POOR OUTPUT VOLTAGE REGULATION

If the AC Power Source exhibits poor voltage regulation the following item may be at fault:

1. The Remote Sense lines are not connected at the same point monitored by the external voltmeter used for load regulation check.

   SOLUTION: Connect AC voltmeter to Remote Sense lines.

6-4 OVERTEMPERATURE LAMP ON

If the power source OVERTEMP lamp is on, the following may be at fault:

1. Ambient temperature is too high.

   SOLUTION: Operate power source between 0 and 55 degrees C.

2. Fan or ventilation holes are blocked.

   SOLUTION: Remove obstructions.

3. Fan not working.

   SOLUTION: Replace fan. Consult factory.

6-5 OVERLOAD LAMP ON

The OVERLOAD lamp comes on when the output load current has exceeded the programmed current limit value. If the AC Power Source OVERLOAD lamp is on, the following items may be at fault:

1. The output is overloaded.

   SOLUTION: Remove the overload.

2. The programmable current limit level is set too low for the load being driven.

   SOLUTION: Compute and reprogram the correct programmable current limit level.

3. The programmable current limit is incorrectly calibrated.

   SOLUTION: Perform the calibration in paragraph 4-4-4.

4. Incorrect AC Power Source configuration. Check the ELT screen. It should show more than 24 hours of operation. If it shows less than 24 hours consult the factory.

6-6 CAN'T PROGRAM AC POWER SYSTEM ON GPIB

If the power source does not respond to IEEE-488 GPIB programming, the following items may be at fault:

1. The power source unit address is incorrect.

   SOLUTION: Update address. See paragraph 3-6-1.

2. GPIB cable is loose at power source rear panel.

   SOLUTION: Check connection, tighten jack screws.

3. The oscillator has failed.

   SOLUTION: Replace the oscillator. See Paragraph 6-10.

6-7 DISTORTED OUTPUT

The AC Power Source output may have a distorted sine wave from the following causes:

1. The power source output is overloaded.

   SOLUTION: Remove the overload or program the current limit to a higher value. Observe power source capabilities. See Section 1.

2. The crest factor of the load current exceeds 2.5. With this condition the distortion will be much higher at frequencies above 100 Hz.

   SOLUTION: Reduce the load or program the current limit to a higher value.

6-8 NO OUTPUT

If the AC Power Source has no output at the rear panel terminal block, TB1, the following items may be at fault:

1. If the Remote Sense lines are not connected correctly, there will be no output. The error message AMP FAULT will also be generated.

   SOLUTION Correctly connect the sense lines. Refer to Paragraph 2-6.

2. When the output is overloaded an error message will be generated and the output relays will open. The error message would be AMP FAULT.

   SOLUTION: Remove the overload. Observe the output power capabilities. Refer to Section 1.

3. There is no input to the power amplifiers from the oscillator. Check the oscillator signals at the system interface connector:

   J5-24 Oscillator Signal
   J5-7 Oscillator common/return

Program 135.0 volts on the 135 volt range. The signal should be 4.74 ±0.5 VAC.

SOLUTION: If there is no signal at the Systems Interface connector replace the oscillator. Refer to paragraph 6-10.

SOLUTION: If the signal at the System Interface connector is greater than 4.74 VAC, it may be necessary to replace the respective amplifier. Refer to paragraph 6-21.

4. The internal fuse, F1, has failed.

   SOLUTION: Replace the fuse. .

6-9 MODULE REMOVAL

Figure 6-1 shows the location of the internal modules and assemblies. The figure shows the Amplifier Module, A7, with the insulator removed.

6-10 OSCILLATOR MODULE REMOVAL/REPLACEMENT

If a fault is found that requires the replacement of the Oscillator Module (assembly 4959-411-1) follow the following steps and refer to Figure 6-1 for the module locations:

1. Turn off the front panel circuit breaker.

2. Remove the Keyboard/Display assembly (Oscillator Module front panel) by loosening the two captive screws on its front panel.

3. Unplug the Oscillator Module, A8, by sliding out the package of PC assemblies with the front panel display.

4. The module is now removed. To replace the module follow these steps in reverse order.

6-11 AMPLIFIER REMOVAL/REPLACEMENT

If a fault has been found that indicates the failure of the amplifier module (assembly 4009-404), check the condition of the +300 VDC fuse before replacing the amplifier. Refer to Figure 6-1 for the location of the fuse.

If it is determined that the amplifier module must be replaced perform the following procedure:

1. Turn off the input circuit breaker.

2. Remove the AC Power Source top cover.

3. Remove the four screws that hold the amplifier module from the far end opposite the connector.

4. Remove the amplifier by lifting its end up and disconnecting from the connector.

5. The amplifier may be replaced by following this procedure in reverse order.

6. Check the amplifier 10 amp fuse located on the DC Supply Board, A6, and replace it if necessary.

7. After an amplifier has been replaced, readjust its gain. Refer to Section 4.

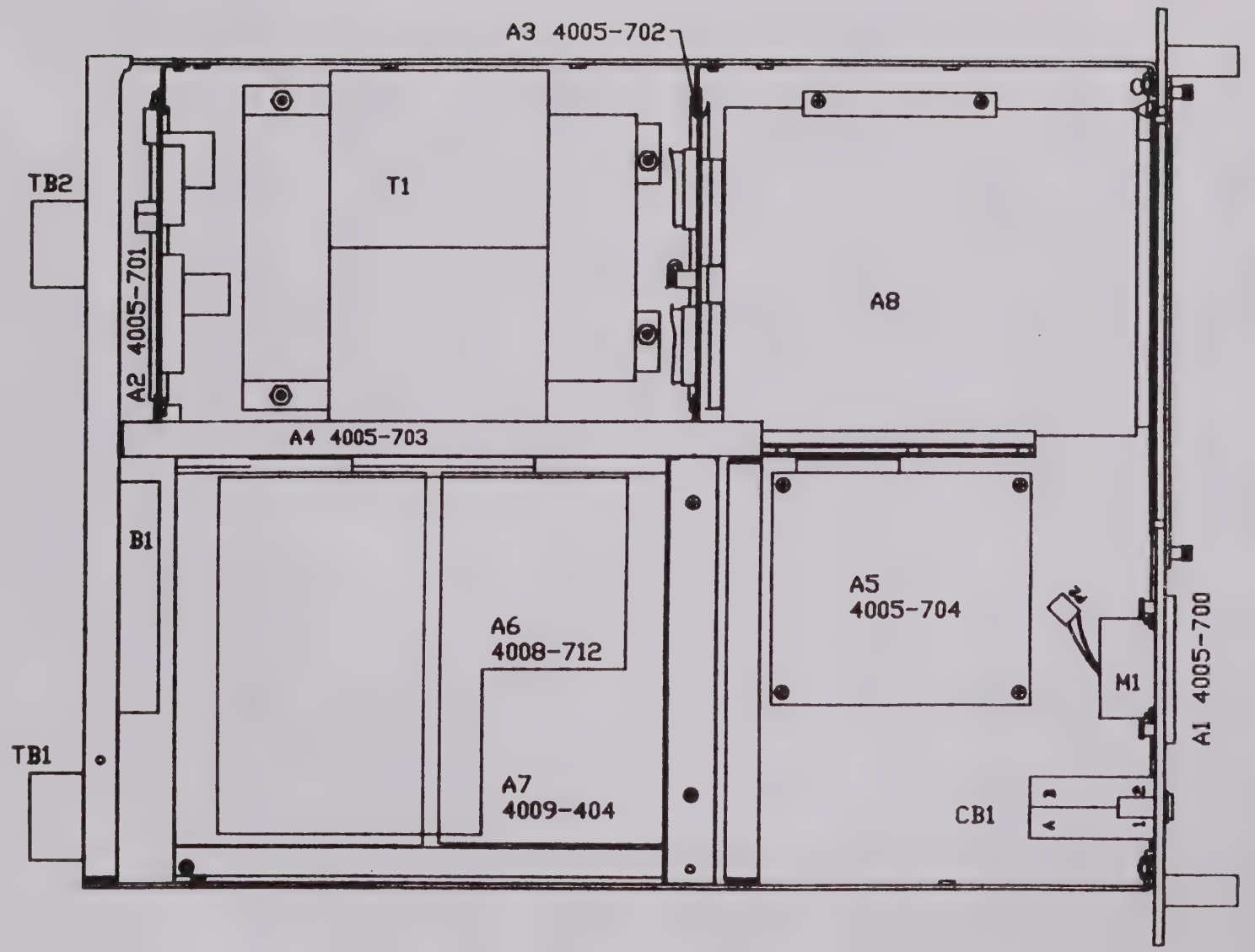


FIGURE 6-1
MODULE LOCATION

SECTION 7

REPLACEABLE PARTS

7-1 GENERAL

7-2 This section contains ordering information and a list of replaceable parts. The list includes the parts description and California Instruments part numbers.

7-3 ORDERING INFORMATION

7-4 In order to ensure prompt, accurate service, please provide the following information, when applicable for each replacement part ordered.

a. Model number and serial number of the instrument.

b. California Instruments part number for the subassembly where the component is located. (PARENT ITEM NO.)

c. Component reference designator. (SEQ NO.)

d. Component description.

e. Component manufacturers' FSCM number. (VENDOR)

f. California Instruments' part number (COMPONENT ITEM NO.)

All replaceable part orders should be addressed to:

California Instruments
Attention: Customer Service
9025 Balboa Avenue
San Diego, California 92123-1509

TOP ASSEMBLY REPLACEABLE PARTS
FOR 1501L
TOP ASSEMBLY NO: 4005-400-1

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION	VENDOR	QTY
A1	4005-700-1	PC ASSY, INDICATOR	16067	1.0
A2	4005-701-1	PC ASSY, RANGE/RELY	16067	1.0
A3	4005-702-1	PC ASSY, OSCILLATOR INTERFACE	16067	1.0
A4	4005-703-1	PC ASSY, MOTHER	16067	1.0
A5	4005-704-1	PC ASSY, CURRENT LIMIT	16067	1.0
A6	4008-702-1	PC ASSY, DC SUPPLY	16067	1.0
A7	4009-404-2	PC ASSY, HEATSINK, SW AMP	16067	1.0
A8	4959-411-1	PC ASSY, MODULE OSC.	16067	1.0
B1	241180	FAN, 4", 48 VDC	23936	1.0

Appendix A

Number	Vendor Name	City	State
0000A	Electricord	Westfield	PA
0000C	Jackson Bros.	Weddon,Surrey	GB
0000S(28564)	OPCDA (Petac Elect. Corp.)	Winsted	CT
0000W	Milton Ross Co.	Southampton	PA
0000Z(52745)	Timco	Los Angeles	CA
000AC	Itac	Santa Clara	CA
000AD(55112)	Plessey (Westlake Cap. Inc.)	Westlake Village	CA
000AG	Lafrance	Philadelphia	PA
000AH(54363)	Jan Crystal	Ft. Myers	CA
000AL(53495)	Data Components, Inc.	Gardena	CA
000AM	Kraus & Naimer	Santa Monica	CA
000AM	Riti Instrument Transformer	Redondo Beach	CA
000AS	Switches Incorporated	Mt. View	CA
000AT(62643)	United Chemi-Con	Rosemont	IL
000AU	JMJ Technical Prod. Inc.	Kendall Park	NJ
000AV(61877)	Semi Processors, Inc.	San Jose	CA
000AW	Micross	Chatsworth	CA
000AX(63078)	Apetronics	Mentor	OH
000AT	Silicon Power Cube Corp.	Long Beach	CA
000AZ(61271)	Fujitsu	Santa Clara	CA
000BA(61964)	Omron Electronics, Inc.	Schaumburg	IL
000BB	Hallmark Metals, Inc.	Glendora	CA
000BC	Tomiba America, Inc.	Tustin	CA
000BD(559B2)	Electronic Essentials	Woodside	NY
000BE(57856)	Kel-Am	Eldon	MO
000BF(55285)	Betquist	Minneapolis	MN
000BG	Panasonic	Secaucus	NY
000BH	Century Components	Canyon Country	CA
000BI(54186)	Micro Power Systems	Santa Clara	CA
000BJ(06776)	Robinson Nugent	New Albany	IN
000BL(13150)	Beau Products (Vernitron)	Laconia	NH
000BM(91725)	Coreoinder (Gerrard AJ & Co.)	Des Plaines	IL
000BO	Mitsuuishi Electronics Amer.	Sunnyvale	CA
000BP	Silicon Power Cube	Long Beach	CA
000BR	Secne	Magnolet	France
000BS	Panel Components Corp.	Santa Rosa	CA
00544	Metal-Cal Div., Avery Prod.	Inglewood	CA
00779	AMP Inc.	Harrisburg	PA
00853	Sangamo Electronic Co.	Pickens	SC
00866	Goe Eng. Co., Inc.	City of Industry	CA
01002	G.E. Co., Ind. & Pwr. Cap. Dept.	John St. Hudson Falls	NY
01121	Allen-Bradley Co.	Milwaukee	WI
01139	G.E. Co., Silicone Prod.	Waterford	NY
01295	Texas Instruments	Dallas	TX
01961	Pulse Engineering, Inc.	San Diego	CA
02111	Spectrol Electronics	City of Industry	CA
02113	Coilcraft, Inc.	Cary	IL
02335	Fairchild Controls Corp.	Hicksville,LI	NY
02375	American Insulating Mach. Co.	Philadelphia	PA
02538	Texas Electronics Co.	Dallas	TX
02660	Amphenol Corporation	Broadview	IL
02768	Illinois Tool Works, Inc. Use Code #72136	Des Plains	IL
02799	General Electric Company	Syracuse	NY
03507	General Electric Company	Syracuse	NY
03797	Eldema Corporation	Compton	CA
03888	Pycrofilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Clairex Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec.	Hartford	CT
04099	Capco, Inc.	Grand Junction	CO
04713	Motorola Semiconductor Prod.	Phoenix	AZ
04729	Universal Components Corp.	Green Brook	NJ
04963	3-M	St. Paul	MN
05245	Coccon Inc.	Chicago	IL
05276	Pomona Electronics., Inc.	Pomona	CA
05397	Kemet, Union Carbide Corp.	Cleveland	OH
05791	Lyn-Tron, Inc.	Burbank	CA
05820	Wakefield Engineering, Inc.	Wakefield	MA
05972	Loctite Corp.	Newington	CT
06383	Panduit Corp.	Tinley Park	IL
06514	Stantron, Wyco Metal Prod.	N. Hollywood	CA
06540	Amacom Elect. Hardware	New Rochelle	NY
06665	Precision Monolithics Inc.	Santa Clara	CA
06776	Robinson Nugent, Inc.	New Albany	IN
06915	Richco Plastics, Co.	Chicago	IL
07088	Kelvin Electric Company	Van Huys	CA
07263	Fairchild Camera & Instr.	Mt. View	CA
07387	Birtcher Corporation	Los Angeles	CA
07556	Unitrack Calabro Plastics	Upper Darby	PA
07633	Epoxy Prod. Co., Allied Prod. Corp.	New Haven	CT
07707	USM Corp. (QSM Fastener Div)	Shelton	CT
07716	IRC Incorporated Use Code #13818	Burrington	IA
07910	Loctite (Auto & Consumer Grp)	Mtn View	CA
08028	Spang Ind. (Magnetics Div)	Sandy Lake	PA
08057	Accurate Rubber and Plastics	San Diego	CA
08065	Spectra Strip (Amphenol)	Garden Grove	
08261	Blinn Delbert Co.	Pomona	CA
08289	Bristol Co. of Canada	Toronoto, Ont	Canada
08353	Ostby & Barton (Vemaline Prod. Div.)	Warwick	RI
08730	Signal Transformer	Brooklyn	NY
08779	GE (Semiconductor Prod. Div)	Auburn	NY
09214	C & K Components	Newton	MA
09353	Burndy Corp.	Norwack	CT
09922	Chicago Switch	Chicago	IL
10389	Cherry/Textron (Fastener Div)	Santa Ana	CA
11815	Elpac Electronics	Santa Ana	CA
12406	Clarostat Mfg.	Dover	NH
12697	Thermalloy Company	Dallas	TX
13103	Vernitron Corp (Beau Prod.)	Laconia	NH
13150	Sperry Corp. Elec. Systems	Great Neck	NY
13504	Burr-Brown	Tucson	AZ
13919	Semtech Corporation	Newbury Park	CA
14099	Elwood Sensors Inc.	Cranston	RI
14604	Cornell-Dubilier Elect. Corp.	Newark	NJ
14655	Hollingsworth Co.	Phoenixville	PA
14726	Electro Cube, Inc.	San Gabriel	CA
14752	Electronic Instruement and Specialty Corp.	Stoneham	MA
14908	ITT Semiconductors	Lawrence	MA
15238	Ametek Enk (Rodan Div)	Anaheim	CA
15454	Elec-trol	Northridge	CA
15636	Fenwell Electronics	Framingham	MA
15801	Amelco Teledyne, Inc.	Mt. View	CA
15818	Amsley	Los Angeles	CA
15912	California Instruements Co.	San Diego	CA
16067	Delco Radio Div., Gen. Mtrs.	Kokomo	IN
16758	Dennison	Framingham	MS
16956	Siliconix, Inc.	Santa Clara	CA
17856	Umpco	City of Industry	CA
18076	Vactec, Inc.	Maryland Heights	MO
18178	Concord Electronics Corp.	New York	NY
18310	Signetics	Sunnyvale	CA
18324	Vishay Instruments, Inc.	Malvern	PA
18612	Scamco Mfg. Co. (Ilco Corp.)	Monterey Park	CA
18677	RCA	Mountaintop	PA
18722	Voltronics Corp.	Hanover	NJ
18736	Robison Company	Hawthorne	CA
19080	Buckeye Stamping Company	Columbus	OH
21604	Solitron Devices (Semi-conductor Group)	Riviera Beach	FL
21845	Elastic Stop Nut Corp.	Van Huys	CA
22599	Product Components Corp.	Hastings-on-Hudson	NY
23050	Pamotor, Inc.	San Francisco	CA
23936	ECC	Burlington	MA
24011	Analog Devices, Inc.	Norwood	MA
24355	General Semiconductor Inc.	Tempe	AZ
24444	Pareico, Inc.	Paramount	CA
24796	Specialty Connector Co., Inc.	Greenwood	IN
24931	AEG-Telefunken Corp.	Summerville	NJ
24972	Amperex Electronic Corp.	Slatersville	RI
25403	Meter Master	Los Angeles	CA
25497	Marathon Electric Mfg. Corp.	Bowling Green	OH
26605	American Iettler, Inc.	Costa Mesa	CA
26806	National Semi-Conductor Crp.	Santa Clara	CA
27014	Cutler-Hammer, Inc.	Milwaukee	WI
27191	Molex	Downers Grove	IL
27264	B & B Motor & Control Corp.	New York	NY
27335	IMB Electronic Products	Santa Fe Springs	CA
27556	Varo, Inc.	St. Jarland	TX
27683	F-Dyne Electronics	Bridgeport	CT
27735	Hughes Aircraft	Newport Beach	CA
27812	Hewlett-Packard Co.	Palo Alto	CA
28480	Heyman Mfg. Company (Heyco)	Kenilworth	NJ
28520	Schlin Ltd.	Rexdale Ont.	Canada
28606	Raynard Inc. Tridair Ind.	Torrance	CA
29272	Susaco Eng. Inc.	El Segundo	CA
29593	International Components Crp.	Asbury Park	NJ
30039	Aavid Engineering, Inc.	Laconia	NH
30161	Dorann Company	Sylmar	CA
30897	Electra/Midland (Mepco/ Electra)	San Diego	CA
30983	Budwig Mfg. Co.	Ramona	CA
31827	Trididge, Inc.	Pittsburg	PA
31951	Intersil	Cupertino	CA
32293	Bivar, Inc.	Santa Ana	CA
32559	Bourns Inc. (Trimpot Div)	Riverside	CA
32997	Jewell Electrical Inst. Inc.	Manchester	NH
33005	Logic Dynamics, Inc.	Gardena	CA
33335	Kinsbacher Murray Co.	Los Angeles	CA
33716	Duconmun, Inc.	Los Angeles	CA
33855	Colber Corp.	Irvington	NJ
33901	Mills Realstor Co.	Los Alamitos	CA
34238	Silicon General	Westminster	CA
34333	Intel Corporation	Santa Clara	CA
34469	Aerovox Canada Ltd.	Amherst NS	Canada
35007	Linear Technology, Inc.	Burlington, Ont	CAN
37964	Ohmite Manufacturing Co.	Skokie	IL
44655	Parker-Kalon	Clifton	NJ
45722	Penn. Eng. and Mfg. Corp.	Doylestown	PA
46384	Midwest Components, Inc.	Muskegon	MI
50157	Monsanto, Electronic Special Products	Cupertino	CA
50522	Electronic Concepts, Inc.	Eatontown	NJ
50558	Mouser Corp.	Santee	CA
50811	Aries Electronics, Inc.	Frenchtown	NJ
51167	Accurate Screw Machine Co.	Nutley	NJ
51506	ICO/Rally	Palo Alto	CA
51705	Circuit Assembly Corp.	Costa Mesa	CA
52072	Timco	Los Angeles	CA
52745	Kintex, Inc.	Buffalo	NY
53076	Data Components, Inc.	Gardena	CA
53495	Edwards Sheet Metal Works	Fredericktown	OH
54363	Power-One Co.	Camarillo	CA
54407	Samtek, Inc.	New Albany	NY
55322	RAF Electronic Hardware, Inc.	Seymour	CT
55566	Sprague Electric Company	North Adams	MA
56289	RCD Components, Inc.	Manchester	NH
56637	United Chem-Con Corp.	Philadelphia	PA
57640	Kel-Am, Inc.	Eldon	MO
57856	Superior Electric Company	Bristol	CT
58474	Thomas and Betts Company	Elizabeth	NJ
59730	International Rectifier Semiconductor Div.	El Segundo	CA
59993	Xicor, Inc.	Milditas	CA
60395	Seeq Technology, Inc.	San Jose	CA
61394	Saronix	Palo Alto	CA
61441	Aromat Corp.	Mountainside	NJ
61529	Pulse Engineering, Inc.	College Park	MD
61735	Danaitron Corp. of America	Torrance	CA
62483	United Chemicon, Inc.	Rosemont	IL
62643	Hitachi America Ltd.	San Jose	CA
62786	Ward Leonard Electric Co.	Mt. Vernon	NY
63743	Star Micronics, Inc.	New York	NY
63791	Allmetal Screw Prod. Co.	Garden City	NY
70118	Beiden Manufacturing Co.	Chicago	IL
70903	Bud Industries, Inc.	Willoughby	OH
71218	Cambridge Thermionic Corp.	Cambridge	MA
71279	Bussman Mfg. Div. McGraw-Edison Co.	St. Louis	MO
71400	CTS Corporation	Elkhart	IN
71450	ITT Cannon Electric, Inc.	Los Angeles	CA
71468	Centralab Div. Globe-Union	Milwaukee	WI
71590	Coto-Coil	Providence	RI
71707	Chicago Miniature Lampworks	Chicago	IL
71744	Cinch Manufacturing Company	Chicago	IL
71785	Dow Corning Corp.	Midland	MI
71984	Elmenco (Electro Motive)	Williamantic	CT
72136	Dialight Corporation	Brooklyn	NY
72619	General Instruments	Newark	NJ
72699	Erie Technological Prod. Inc.	Erie	PA
72982	Beckman Instruments, Inc.	Fullerton	CA
73138	Consolidated Electronic Wire and Cable Corp.	Chicago	IL
73612	Federal Screw Products, Inc.	Chicago	IL
73734	Heinemann Electric Company	Trenton	NJ
74193	Harvey Hubbell, Inc.	Bridgeport	CT
74545	Illinois Condenser Co.	Chicago	IL
74640	E.F. Johnson Company	Waseca	MN
74970	TRW Electronic Components	Philadelphia	PA
75042	Kulka Electric Corporation	Mt. Vernon	NY
75382	Leviton Mfg. Co.	Little Neck	NY
75582	Littlefuse, Inc.	Des Plaines	IL
75915	Minor Rubber Co., Inc.	Bloomfield	NJ
76385	Pabst Eng. Equipment Co.	Elizabeth	NJ
77062	United-Carr Inc., Fatwin Div	Waterbury	CT
77132	Potter and Blumfield Div, AMF	E. Princeton	IN
77342	Shakeproof Div, IL Tool Works	Chicago	IL
78189	Tinnerman Products, Inc.	Cleveland	OH
78553	Johns-Manville Products Corp	Chicago	IL
79130	Waldes Kohinoor Inc.	Long Island City	NY
79136	Ilerick Mfg. Corp.	New Rochelle	NY
79963	Mepco/Electra	Morristown	NJ
80031	United Transformer Co.	New York	NY
80223	Bourns, Inc.	Riverside	CA
80294	High Voltage Engineering Corp (Anderson Pwr Prod. Div)	Brighton	MA
80495	Triad Transformer Corp.	Venice	CA
81095	Winchester Electronics	Oakville	CT
81312	(Fed. Spec) Promulgated by General Services Administration Washington DC		
81348	Military Specification or Commercial Generic Number		
81349	Airpax Corp.	Cambridge	MD
81541	Reco Products Co.	Chicago	IL
81603	Bentley-Harris Mfg Co.	Lionville	PA
81851	Standard Grigsby	Aurora	IL
82104	Switchcraft, Inc.	Chicago	IL
82189	Rotron Mfg. Co., Inc.	Woodstock	NY
82877	Vector Electronics, Inc.	Sylmar	CA
82899	Herman H. Smith, Inc.	Brooklyn	NY
83330	Elco Tool & Screw Corp.	Rockford	IL
83486	Brady W.H. Co.	Milwaukee	WI
85480	RCA	Harrison	NJ
86684	Seastrom Mfg. Co., Inc.	Glendale	CA
86928	Marco-Oak Industries	Anaheim	CA
87034	Useco Div., Litton Ind.	Van Nuys	CA
88245	Mallory Capacitor Co.	Indianapolis	IN
90201	Augat, Inc.	Attleboro	MA
91508	Oale Electronics, Inc.	Columbus	NE
91637	Elco Corporation	Willow Grove	PA
91662	Industrial Devices, Inc.	Edgewater	NJ
91802	Keystone Electronics Corp.	New York	NY
91833	National Tel-Tronics	Readville	PA
91967	Alpha Wire Corp.	Elizabeth	NJ
92194	Pentagon Products Co.	Washington	DC
93303	Southco, Inc.	Lester	PA
94222	Magnecraft Electric Co.	Chicago	IL
94696	Alco Electronic Prod., Inc.	Nw. Andover	MA
95146	RCA	Cincinnati	OH
95303	Methode Manufacturing Corp.	Rolling Meadows	IL
95354	Arnold Engineering Co.	Marengo	IL
95566	Weckesser Company, Inc.	Chicago	IL
95987	Military Std		
96906	Electronic Engineering Co.	Santa Ana	CA
97525	Rubber Teck, Inc.	Gardena	CA
98159	Seelecto Corp.	Mamaroneck	NY
98291	Zero Mfg. Co. (West)	Burbank	CA
98378	IERC	Burbank	CA
98978	Protective Closures Co., Inc. (Capiugs Div)	Buffalo	NY
99017	Bell Industries, Inc.	Delavan	WI
99217	Permacell	New Brunswick	NJ
99742	IMC	Maywood	CA
99743	Delevan Electronics Corp.	Aurora	NY
99800			

Revision K
June 17, 1986

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS CORPORATION warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses, and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned freight prepaid, and when examination reveals that the fault has not occurred because of misuse, abnormal conditions of operation, user modification, or attempted user repair. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair, if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS or its local representative, giving full details of the difficulty, including the model number and serial number. On receipt of this information, service information or a Return Material Authorization (RMA) number will be given. Add RMA No. to shipping label. Pack instrument carefully to prevent transportation damage, affix label to shipping container, and ship freight prepaid to the factory. CALIFORNIA INSTRUMENTS shall not be responsible for repair of damage due to improper handling or packing. Instruments returned without RMA No., or freight collect will be refused. Instruments repaired under Warranty will be returned by prepaid surface freight. Instruments repaired outside the Warranty period will be returned freight collect, F.O.B. CALIFORNIA INSTRUMENTS, San Diego, CA. If requested, an estimate of repair charges will be made before work begins on repairs not covered by the Warranty.

DAMAGE IN TRANSIT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed immediately with the carrier. A full report of the damage should be obtained by the claim agent, and a copy of this report should be forwarded to us. CALIFORNIA INSTRUMENTS will prepare an estimate of repair cost and repair the instrument when authorized by the claim agent. Please include model number and serial number when referring to the instrument.

MP MASTER
MA28332